



THE UNIVERSITY
OF ILLINOIS
LIBRARY

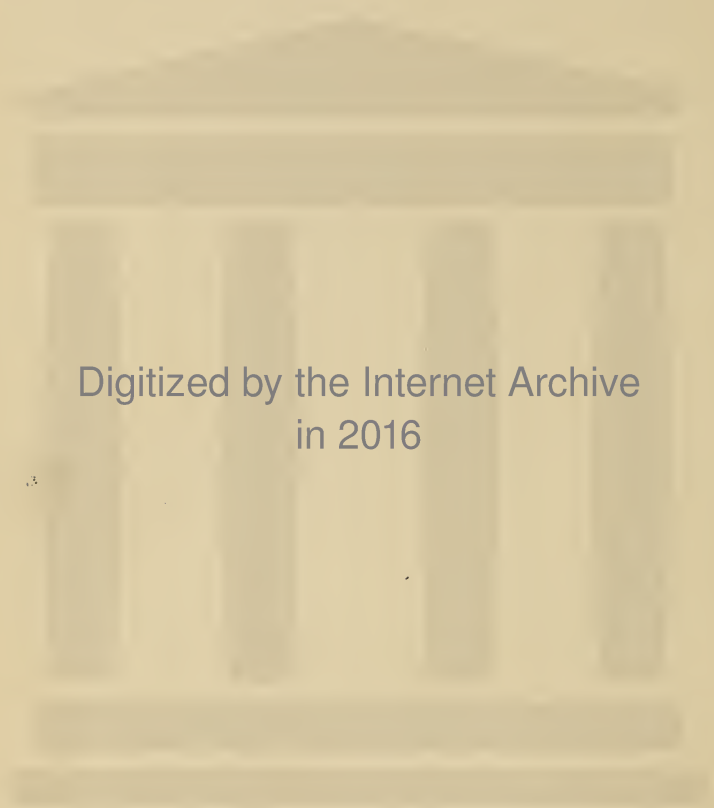
630.7

Oh33c

no.88-119

cop.2

AGRICULTURAL
LIBRARY



Digitized by the Internet Archive
in 2016

<https://archive.org/details/circular8811ohio>

1.072
152
200/3

CIRCULARS
of the
AGRICULTURAL EXPERIMENT STATION
OHIO

CIRCULARS 88-119

January 1909-1911

Wooster

1911



630.7

Oh33c

no 88 - 119

cop 2

TABLE OF CONTENTS

- 88--Recent experiments with oats by C. G. Williams
- 89--State fair meeting of the Ohio state horticultural society, Columbus, Ohio, September 2, 1908
- 90--Seasonal report of potatoes--1908
- 91--Alfalfa culture by C. G. Williams
- 92--Plans and summary tables of the experiments at the Central Farm, Wooster, on the maintenance of soil fertility arranged for reference in the field, March 20, 1909
- 93--Carriers of phosphorus in fertilizers by C. E. Thorne
- 94--Report of horticultural inspection by F. H. Ballou
- 95--Apple spraying in 1908 by H. A. Gossard
- 96--Essentials of successful field experimentation by C. E. Thorne
- 97--Work of the department of cooperative experiments by L. H. Goddard
- 98--Minor items of farm equipment by L. W. Ellis
- 99--Cooperative dairy work by L. H. Goddard and M. O. Bugby
- 100--Centers of agricultural production in Ohio by L. H. Goddard
- 101--Illustrative exhibits at state and county fairs by L. H. Goddard and W. A. Lloyd

358511

- 102--Spraying to kill weeds--some useful methods by
A. D. Selby
- 103--Autumn meeting of the Ohio state horticultural
society, Little Hocking, September 17, 1909
- 104--Plans and summary tables of the experiments at
the Central Farm, Wooster, on the maintenance
of soil fertility arranged for reference in
the field, August 15, 1910
- 105--Floats by E. W. Gaither
- 106--Seeding lawns and permanent pastures
- 107--Successful alfalfa and truck farm in south-
eastern Ohio by W. A. Lloyd
- 108--Orchard practice by W. J. Green
Starting an apple orchard
- 109--Orchard spraying suggestions for 1911 by W. J.
Green, A. D. Selby and H. A. Gossard
- 110--Treatment of artificial tree plantations by
Edmund Secrest
- 111--Management of clover in corn belt rotations
by J. A. Drake
- 112--Commercial apple orcharding in Ohio by H. A.
Gossard
- 113--Alfalfa in Ohio--a field study by W. M. Cook
- 114--Plans and summary tables of the experiments at
the Central Farm, Wooster, on the maintenance
of soil fertility, arranged for reference in
the field, June 23, 1911

115--Chinch bug by H. A. Gossard

116--Rural population of Ohio; where is it increasing
and decreasing? Why? by L. H. Goddard

117--Varieties of corn in Ohio by G. T. Abbott

118--Farm poultry...investigation of the profitable-
ness of poultry when kept under farm condi-
tions by W. A. Lloyd and W. L. Elser

119--Cooperative forestry work by Edmund Secrest

Ohio Agricultural Experiment Station.

CIRCULAR No. 88. -119

WOOSTER, OHIO, FEBRUARY 15, 1909.

RECENT EXPERIMENTS WITH OATS.

BY C. G. WILLIAMS.

The experiments reported in the following pages have to do with comparative tests of different varieties of oats, together with a description of the same, relative to length of season, stiffness of straw, character of panicle and color of grain; the use of northern grown seed; the relation of rate of seeding to yield, and tests of a few varieties of barley, spring wheat and emmer.

The Station tests from 50 to 60 varieties of oats each season upon tenth-acre plots. They are grown in a four-course rotation of corn, oats, wheat and clover, with which is seeded a little timothy. Eight to ten tons of phosphated manure are applied to the clover sod during the winter, which is plowed in for corn. Three hundred and fifty to four hundred pounds per acre of a mixture of steamed bone, acid phosphate, nitrate of soda and muriate of potash are applied to the wheat crop, but no manure or fertilizer is applied directly to the oats.

A uniform check is inter-planted every third plot with the varieties of oats tested. The Wideawake oats have been used as check each year. The yields of the varieties tested are first corrected by the check plots, before being compared with each other.

In Table I is given the yield of grain and weight per bushel of 25 varieties, as grown each year for the past five years, and in the final columns the five-year average yield of grain, weight per bushel and pounds of straw per bushel of grain. The several varieties are arranged in the order of their rank as to yield per acre.

It will be understood, of course, that all yields of oats are computed at 32 pounds per bushel, regardless of their test weight per bushel. In view of this fact it will be noted that nature was prepared to break all records for us in 1908, providing the quality had not been affected by the unfavorable season.

Attention is called to the variation in yield and weight per bushel the different seasons, as shown by the yearly average of the 25 varieties. Seasonal conditions, including climatic, pathological and entomological factors, are mainly responsible for this variation. The four ranges of plots upon which these tests have been conducted are a very even body of land, and similar treatment for fifteen years has made the soil conditions still more uniform.

TABLE I—Comparative test of varieties of Oats.
Yield per acre and weight per bushel.

Name of variety.	1904		1905		1906		1907		1908		5-year average	
	Yield Bus.	Weight per bu. Lbs.	Yield Bus.	Weight per bu. Lbs.	Yield Bus.	Weight per bu. Lbs.	Yield Bus.	Weight per bu. Lbs.	Yield Bus.	Weight per bu. Lbs.	Yield Bus.	Weight per bu. Lbs.
Siberian.....	93.66	32.00	65.09	27.75	78.88	28.75	49.06	26.50	65.63	24.50	70.46	27.90
Sixty Day.....	87.16	30.75	53.62	27.00	71.37	29.25	36.35	24.00	73.72	25.00	69.36	26.30
Improved American.....	85.06	30.75	59.45	24.50	81.21	25.50	45.47	27.50	72.18	24.50	68.99	26.55
Illinois German.....	76.35	31.75	67.19	27.75	79.61	26.25	47.55	30.25	74.14	23.50	68.97	27.90
Joanette.....	79.74	31.50	66.40	27.75	81.26	28.50	43.58	28.00	77.14	28.00	68.94	28.75
Green Mountain	82.54	30.50	58.96	26.00	83.23	25.25	49.03	27.50	73.69	22.50	68.70	26.35
Big Four.....	82.32	31.75	68.48	29.50	82.55	30.25	49.23	29.75	68.86	22.50	68.34	29.15
Silver Mine.....	84.07	31.75	64.50	31.50	82.55	30.50	47.14	32.25	60.12	22.00	67.68	29.85
Czar of Russia.....	71.69	31.75	63.72	30.00	81.62	28.50	45.69	30.25	71.03	24.25	66.75	28.95
Morgan Peller.....	76.47	31.50	62.18	28.00	80.63	26.50	45.24	30.25	69.35	22.00	66.55	27.05
American Banner.....	83.40	31.25	58.18	26.00	77.59	27.50	47.81	29.00	65.78	22.00	66.20	27.50
Wilson's Prolific.....	78.27	31.50	64.22	28.00	76.81	28.00	54.49	28.50	67.22	21.00	65.21	27.80
Lincoln.....	76.52	32.50	59.24	28.00	80.95	30.00	46.60	32.00	61.72	21.50	65.21	26.80
Twentieth Century.....	72.39	31.50	60.95	28.50	80.58	27.00	40.87	32.00	60.77	21.00	63.83	26.00
Swedish Select.....	81.89	32.00	59.95	26.50	71.69	27.00	47.50	26.75	66.75	23.50	63.83	26.10
Golden Pleece.....	70.78	32.00	51.84	26.50	74.21	26.50	36.48	28.50	70.69	23.25	62.99	26.10
Monarch.....	74.68	31.75	59.56	28.00	73.60	26.50	44.78	30.75	66.75	23.50	62.99	26.10
Seizure.....	73.83	31.75	60.79	23.00	74.81	31.25	43.78	30.75	69.41	23.25	61.63	29.15
Long's White Tartar.....	73.66	31.25	44.33	26.50	86.97	31.25	38.23	33.50	51.09	20.00	61.63	24.25
Alaska.....	72.51	32.50	63.65	28.25	86.97	32.25	50.63	33.50	51.09	23.50	61.34	29.20
Watson.....	73.89	32.25	47.24	27.25	71.46	28.75	44.71	33.25	49.86	22.25	60.01	29.45
Widewake.....	71.26	32.00	56.65	28.00	78.08	26.75	51.13	33.25	50.19	22.25	59.46	28.55
Welcome.....	73.76	32.00	55.25	26.50	72.24	28.75	48.70	30.50	47.21	24.25	59.43	27.35
Clydesdale.....	77.46	32.50	46.59	25.00	74.74	27.25	46.68	28.75	48.55	21.00	58.86	26.90
Early Champion.....	62.80	31.50	56.58	29.50	67.55	32.50	42.73	28.75	62.87	21.00	58.66	28.65
Yearly average.....	77.75	31.61	59.16	27.58	77.9	28.47	45.25	29.17	62.02	22.26	64.69	27.82
												44.4

Straw
per bu.
Lbs.

VARIETY TEST OF 1908.

There are necessarily some few changes each year in the varieties of oats grown. New varieties are being continually introduced and room must be made for them in the Station's test plots. Accordingly the poorer varieties are weeded out and their places taken by the newcomers. In 1908, some new importations were introduced from Svalof, Sweden, viz.: Beardless Propsteier, Black Mogul, Golden Rain, Hvitling, White Ligowa and White Propsteier, also the Regenerated Swedish Select, from the Gartons, of England.

In Table II is given a list of the varieties tested in 1908. These varieties are described with reference to length of season, stiffness of straw, character of panicle, color of grain, yield of grain per acre, weight per bushel and pounds of straw per bushel of grain.

TABLE II—Variety test of oats, 1908.

Description of varieties.

Name of variety	Length of season Days	Stiffness of straw	Side or branching	Color of Grain	Yield of grain per acre Bus.	Weight per bu. Lbs.	Pounds of straw per bu of grain.
Alaska.....	101	85	Br.	White	49.86	23.00	56.7
American Banner ..	105	90	Br.	White	65.78	22.00	50.3
Beardless Propsteier.....	109	94	Br.	Yellow	53.74	23.25	44.1
Black Mogul.....	111	96	Br.	Black	44.25	19.50	61.8
*Big Four.....	105	87	Br.	White	58.44	24.50	49.0
Clydesdale.....	104	89	Br.	White	48.55	21.00	68.4
Czar of Russia.....	106	85	Br.	White	71.03	24.25	50.9
Danish.....	107	84	Br.	Yellow	72.12	22.50	42.8
Dun.....	109	78	Br.	Gray	49.98	22.25	68.8
Early Champion.....	100	79	Br.	White	62.87	21.00	52.4
Golden Fleece.....	106	83	Br.	White	70.69	24.50	40.7
Golden Rain.....	107	96	Br.	Yellow	61.98	28.75	40.9
Green Mountain.....	106	87	Br.	White	68.86	22.50	48.7
Hvitling.....	108	96	Br.	White	63.55	26.00	35.4
Illinois German.....	106	85	Br.	White	74.14	23.50	44.6
Improved American.....	106	90	Br.	White	67.18	24.50	45.2
Selection 6143.....	105	89	Br.	White	68.96	22.25	47.6
Joanette.....	106	89	Br.	Black	73.69	28.00	46.9
Lincoln.....	105	87	Br.	White	61.75	21.50	54.7
Long's White Tartar.....	104	92	Side	White	51.09	23.50	61.7
Minnesota No. 6.....	107	85	Br.	White	67.08	27.00	37.9
Monarch.....	101	82	Br.	Black	59.41	23.25	64.8
Morgan Feller.....	106	88	Br.	White	69.35	23.25	47.7
Pride of Ohio.....	106	90	Br.	White	69.51	23.50	47.8
Garton's Regenerated Swedish Select	105	65	Br.	White	62.37	25.50	37.9
Garton's Regenerated Swed- ish Select (heavy seeding)	105	55	Br.	White	53.15	25.75	43.5
Seizure.....	109	92	Side	Yellow	58.47	20.00	62.9
Sensation.....	105	86	Br.	White	68.00	24.50	42.0
Siberian.....	105	82	Br.	Wh. & Yel	65.63	24.50	40.7
Selection 6203.....	104	82	Br.	White	71.36	26.50	36.6
Silver Mine.....	104	85	Br.	White	60.12	22.00	50.7
Sixty Day.....	95	85	Br.	Yellow	75.72	25.00	31.4
*Sixty Dakota (N. Dakota) ..	94	75	Br.	Yellow	69.04	25.00	34.3
Sparrow-bill.....	108	84	Br.	White	48.79	22.00	71.4
Storm King.....	104	92	Side	White	51.07	21.50	63.7
Swedish Select.....	105	82	Br.	White	66.75	23.75	42.5
Twentieth Century.....	105	82	Br.	White	66.37	24.00	44.5
Watson.....	104	92	Side	White	50.19	22.25	63.7
Welcome.....	104	87	Br.	White	47.21	22.00	62.1
White Ligowa.....	105	96	Br.	White	65.41	25.75	33.4
White Propsteier.....	109	96	Br.	White	54.10	23.25	51.6
Wideawake.....	105	78	Br.	White	50.19	24.25	67.7
Wilson's Prolific.....	104	88	Br.	White	57.22	21.00	60.2
Winter Oats.....	...	85	Br.	Gray	66.56	32.50	46.6

*Seeded a few days later owing to delay in getting seed.

The rate of seeding was uniformly 10 pecks per acre, *by measure*, except in the case of the new Swedish importations, which were seeded 8 pecks, by measure, owing to a scarcity of seed, and the plot of Regenerated Swedish Select described as "heavy seeding", which, by request of the Messrs. Garton, was seeded at the rate of 20 pecks by measure, or over 28 pecks by weight.

Attention is called to the fact that this heavy seeding reduced the yield of the Regenerated Swedish Select oats 9.22 bushels per acre, and that the normal rate of seeding of this variety is 4.38 bushels per acre below the "unregenerated" Swedish Select. This, however, is but one year's test and future results may be quite different.

Some of the Svalof selections show up very well, all things considered; particularly the White Ligowa and the Hvitling, but further testing is necessary. The seed of these selections tested above 40 pounds per bushel and the Gartons Regenerated Swedish Select, 46 pounds, due probably to the climatic conditions under which they were grown, but one season's growth in Ohio puts them about on a level with normal Ohio oats so far as weight per bushel is concerned.

NORTHERN GROWN SEED.

In 1904, this Station introduced two varieties of oats from Canada, viz.: the Siberian and the Joannette. The seed of these varieties weighed, when introduced, twelve pounds per bushel more than the average of our own varieties. They have been grown each season from 1904 to 1908, inclusive. Table III shows the effect of our Ohio environment upon them.

TABLE III—Canadian oats in Ohio. Increase (+) or decrease (—) in yield per acre and increase or decrease in weight per bushel, each year, as compared with average of 25 varieties among which they have been continuously grown.

Variety	1904		1905		1906		1907		1908	
	Yield Bus.	Weight Lbs.	Yield Bus.	Weight Lbs.	Yield Bus.	Weight Lbs.	Yield Bus.	Weight Lbs.	Yield Bus.	Weight Lbs.
Siberian...	+15.91	+0.39	+5.93	+0.17	+0.93	+0.28	+3.81	-2.67	+3.61	+2.24
Joannette...	+2.01	-0.11	+7.24	+0.17	+3.31	+0.03	-1.67	-1.17	+11.67	+5.74
Average...	+8.96	+0.14	+6.58	+0.17	+2.12	+0.15	+1.07	-1.92	+7.64	+3.99

The Siberian oats yielded higher the first season than they have since yielded. The Joannette oats yielded highest the last year of the five. Averaging the two varieties as to yield, the fifth year stands 1.32 bushel below the first.

In weight per bushel, both varieties have a wider lead the fifth year than they had the first year.

As bearing further upon the question of northern grown seed, two varieties from Montana and one from North Dakota were grown beside Ohio grown seed of the same varieties in 1908. Upon the average the Ohio grown seed exceeded the other in yield by 1.35 bushel per acre.

As to the advisability of using seed oats from the north and north-west when for any reason the Ohio crop is short, there seems to be little chance for loss. The northern grown seed may be expected to give about as satisfactory results as similar native varieties and seems to do about as well the first year as thereafter.

RATE OF SEEDING.

Table IV gives the results of a series of tests of different rates of seeding, ranging from 4 to 11 pecks, and extending over eleven years. Four different varieties have been used in this work, and sixteen distinct tests conducted. The seed used has been carefully recleaned in every instance. Taking up the different varieties used it will be observed that the Seizure variety gives its highest average yield from 11 pecks of seed per acre; the Wideawake variety from 9 pecks; the Improved American from 11 pecks and the Siberian from 9 pecks. Combining these sixteen tests in one general average, 11 pecks of seed per acre have given the highest yield, and though this lead is but slight, still it is enough higher to a little more than pay for the extra seed.

The weight of grain per measured bushel has increased with the rate of seeding up to 10 pecks per acre. The average weight per bushel from the three lower rates of seeding is 26.46 lbs.; from the three higher (omitting the 12 pecks, which was included in only six of the sixteen tests) 27.97 lbs.

The yield of straw per acre, with both the Seizure and Wideawake varieties, is greatest from 5 pecks of seed per acre, and least from 11 pecks. This, however, is reversed with the Improved American variety, the greatest yield of straw being from 11 pecks of seed and the least from 4 pecks. By consulting Table I it will be noted that the Wideawake and Seizure varieties have the most straw in proportion to grain of any of the varieties reported.

TABLE IV—The relation of rate of seeding to the yield of grain and straw.

Pecks of seed per acre	4		5		6		7		8		9		10		11		12	
	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.	Grain per acre Bus.	Straw per acre Lbs.
SEIZURE.																		
1898.....	26.09	2,030	32.49	2,170	36.32	2,352	38.27	2,425	41.32	2,418	45.22	2,527	44.29	2,252	39.84	1,100	.....	.....
1899.....	22.18	1,245	25.15	950	26.24	965	30.93	1,030	32.49	1,005	36.24	985	37.65	985	52.60	1,442	.....	.....
1900.....	54.45	3,312	57.73	3,252	56.24	2,970	48.98	2,432	51.56	2,500	53.75	2,705	52.34	1,410	36.71	1,515	.....	.....
1901.....	21.79	1,512	27.65	1,495	25.15	1,435	28.43	1,360	31.24	1,480	35.93	1,550	34.99	1,410	36.71	1,515	.....	.....
1902.....	50.46	2,830	55.13	3,127	56.56	3,035	57.34	3,030	64.53	2,940	65.31	2,785	63.43	2,765	63.67	2,637	.....	.....
Average.....	34.99	2,186	39.65	2,199	40.10	2,151	40.81	2,055	44.23	2,069	47.29	2,130	46.54	1,977	48.21	1,923	.....	.....
WIDEAWAKE																		
1898.....	36.87	2,220	40.70	2,102	37.18	1,800	42.96	2,095	39.53	1,875	37.18	1,905	38.28	1,950	32.03	1,225	.....	.....
1899.....	36.48	1,307	37.73	1,387	38.51	1,227	43.76	1,402	43.90	1,365	43.12	1,400	44.13	1,307	51.17	2,082	.....	.....
1900.....	47.73	2,367	48.95	2,277	49.84	2,040	48.89	2,110	50.47	1,960	53.28	2,180	52.88	2,207	44.37	1,591	.....	.....
1901.....	36.39	1,666	40.14	1,826	38.11	1,791	40.15	1,736	40.61	1,411	42.34	1,686	41.94	1,638	60.15	2,440	.....	.....
1902.....	54.13	2,557	60.42	2,465	60.85	2,622	59.29	2,417	59.60	2,477	60.78	2,295	60.23	2,362	49.29	1,807	.....	.....
1903.....	39.37	1,664	41.44	1,683	39.64	1,681	43.35	1,727	48.31	1,898	47.03	1,760	46.79	1,757	49.29	1,807	.....	.....
1905.....	46.88	2,450	50.16	2,555	52.34	2,705	51.80	2,732	51.41	2,725	50.16	2,515	49.53	2,725	48.98	2,442	.....	.....
Average.....	42.55	2,033	45.68	2,042	45.21	1,981	47.17	2,031	47.69	1,959	47.70	1,963	47.68	1,994	47.66	1,931	.....	.....
IMPROVED AMERICAN																		
1905.....	52.42	2,342	55.08	2,337	56.25	2,300	56.02	2,257	60.16	2,315	59.59	2,492	59.22	2,505	62.97	2,605	58.28	2,375
1907.....	38.59	1,595	41.56	1,760	42.19	1,650	44.30	1,902	44.22	1,765	46.17	1,842	46.88	1,770	47.03	1,765	47.89	1,897
1908.....	67.19	2,500	70.23	2,712	72.27	2,707	71.25	2,620	67.89	2,627	69.92	2,782	69.14	2,917	69.14	2,837	70.00	2,950
Average.....	52.73	2,146	55.62	2,269	56.90	2,219	57.19	2,259	57.42	2,236	58.56	2,372	58.41	2,397	59.71	2,402	58.72	2,401
SIBERIAN																		
1906.....	66.64	2,667	66.56	2,610	67.81	2,430	70.23	2,382	70.00	2,360	72.66	2,265	71.87	2,340	68.12	2,140	69.53	20.95
Combined average	43.60	2,141	46.77	2,169	47.22	2,107	48.50	2,104	49.83	2,070	51.17	2,111	50.85	2,085	51.86	2,045	.....	.....
WEIGHT PER MEASURED BUSHEL—LBS.																		
Combined average	26.53	.....	26.61	.....	26.24	.....	26.86	.....	27.58	.....	27.78	.....	28.09	.....	28.05	.....	.....	.....

BARLEY AND OTHER SPRING GRAINS.

In Table V is given the yield of various small spring grains which have been tested from time to time in the hope of finding a substitute for oats or winter wheat. Owing to the wide variation in weight per bushel of the crops compared, all yields are given in pounds per acre. With the exception of emmer (commonly called speltz or spelt) none have been tested the full five years. It will be noted that under the Station conditions the five-year average yield of 25 varieties of oats exceeds the five year average yield of emmer by over 46 percent.

TABLE V—Barley and other spring crops.

Yield in pounds per acre and weight per bushel.

Name of crop	1904	1905	1906	1907	1908	Average	
	Pounds per acre	Pounds per acre	Pounds per acre	Pounds per acre	Pounds per acre	Pounds per acre	Weight per bu.
Emmer.....	1,645	910	1,275	1,450	1,782	1,412	29.68
Ohio Beardless Barley.....	1,242	877	.....	.....	.....	1,059	38.00
Champion Beardless Barley.....	.....	.....	1,567	.....	*	1,567	37.00
Highland Chief Barley.....	930	.....	.....	.....	.....	930	43.50
Black Hulless Barley.....	2,010	1,062	1,442	.....	.....	1,505	58.00
Manshury Barley.....	1,850	1,887	2,002	.....	.....	1,913	38.62
Oderbrucker Barley.....	.....	.....	.....	.....	2,115	2,115	40.75
Primus Barley.....	.....	.....	.....	.....	1,755	1,755	42.00
Princess Barley.....	.....	.....	.....	.....	1,675	1,675	39.50
Wild Goose Spring Wheat.....	840	940	700	.....	.....	827	42.37
Durum Spring Wheat.....	.....	.....	882	.....	1,090†	986	44.37
Minn. No. 169 Spring Wheat.....	.....	.....	520	460	.....	490	39.00
Mammoth Spring Rye.....	.....	.....	.....	1,005	1,435	1,220	50.50
Siberian Oats.....	2,997	2,083	2,524	1,570	2,100	2,255	27.90
Sixty Day Oats.....	2,789	1,780	2,284	1,822	2,423	2,220	26.30
Average of twenty-five varieties of oats.....	2 488	1 893	2 494	1 448	1 985	2 062	27.82

*Seed of this variety failed to grow.

†Kubanka variety.

In so far as the barleys are concerned, with the exception of the Oderbrucker and Manshury, there is little competition with oats. The beardless sorts we have thus far tested have proved decidedly inferior to oats. The Ohio Beardless was grown two seasons—1904 and 1905. Comparing these yields with the average of the afore-mentioned 25 varieties of oats for the same seasons, we find the oats over 106 percent in the lead. Comparing the Champion Beardless with oats in 1906, as above, the oats lead by over 59 percent. It had been planned to test the Champion Beardless barley in 1908, but the seed purchased proved worthless.

The bearded barley, Oderbrucker, would seem likely to be a close competitor of oats and will be tested further.

It is, perhaps, of moment to show the digestible nutrients in oats and barley.

TABLE VI*—Digestible nutrients in 100 pounds of—

Crop.	Dry matter Lbs.	Protein Lbs.	Carbo-hydrates Lbs.	Fat Lbs.
Oats.....	89.0	9.25	48.34	4.18
Barley.....	89.1	8.69	64.83	1.60

*Farmers' Bulletin No. 22, U. S. D. A.

Of the spring wheats tested, not only has the yield been found unsatisfactory but the quality has been such as to make it unfit for anything save stock feed. Minnesota No. 169, which has yielded so poorly when seeded in the spring, as shown by the above table, has given a yield of 33 bushels when seeded in the fall with the winter varieties.

For the purpose of comparison, the yields of two of the best varieties of oats, as well as the average of 25 varieties, are included in Table V.

WINTER OATS.

This Station is testing a strain of winter oats which volunteered to go through the winter of 1905-1906 with our variety wheat, being self-sown from the spring crop of oats. Enough seed was saved from this volunteer crop to seed a twentieth-acre plot in the fall of 1906. This plot yielded at the rate of 46.41 bushels per acre in 1907, the average of all spring varieties being 44.24 bushels. In weight per bushel it exceeded the spring varieties by 3.08 pounds per bushel. This winter strain was seeded again in the fall of 1907 and as harvested in 1908 yielded 66.56 bushels per acre, the average of all the spring varieties tested being 61.51 bushels. In weight per bushel it exceeded the spring varieties by 8.92 pounds. It ripens from 8 to 10 days earlier than the average of the spring varieties. It has probably not yet been seeded heavily enough for best results. Whether it will prove hardy and worthy of introduction is yet uncertain. Further testing is necessary before it can be recommended.

NO OATS FOR SALE.

The Station has no seed oats for sale. Through its Department of Cooperative Experiments it will arrange for small plot experiments with such farmers as desire to test different varieties in cooperation with the Station.

134 Page
Ohio Agricultural Experiment Station.

CIRCULAR No. 89.

Horticultural Series No. 2

WOOSTER, OHIO, FEBRUARY 20, 1909.

STATE FAIR MEETING OF THE OHIO STATE
HORTICULTURAL SOCIETY

HELD AT COLUMBUS, OHIO, SEPTEMBER 2, 1908.

The program for this meeting provided for a series of brief crisp papers and addresses devoted to "Valuable Lessons of Naught-eight" from various standpoints.

Considering the busy time at which this meeting was held, and the fact that State Fair visitors and employees are usually quite tired when evening comes, this session was well attended and liberal part was taken by the speakers listed on the program.

While the financial status of the Society was briefly discussed, no business was transacted at this meeting aside from the reception of a number of new members and a few renewals, and the reading of the report of the committee named by President Cox to examine the new fruits exhibited.

It is to be regretted that a small number of subjects presented "off-hand" at this meeting cannot be included in this report. Diligent effort has been made to secure written outlines of these talks by those who gave them, and this report has been held back four months in hope of securing this additional matter. Further delay was not possible, as reports of subsequent meetings will, even now, conflict in the printery.

VALUABLE LESSONS OF NAUGHT-EIGHT

FROM THE PATHOLOGICAL STANDPOINT.

BY A. D. SELBY, BOTANIST

Ohio Agricultural Experiment Station, Wooster, Ohio.

The speaker has already presented what appears to him to be two phases of the great lesson of 1908, viz., the severe outbreak of apple scab for the year, and the lessons as to its prevention. Second, the promising character of two relatively new fungicides: the one proposed by the writer and named "Bordeaux mixture and Iron sticker," the second proposed by W. M. Scott, of the United States Department of Agriculture called "self-boiled lime-sulphur mixture." Enough emphasis has possibly been placed upon these two lessons in the paper presented at the Gypsum meeting, August 12th. Put in a nut-shell, however, the lesson of 1908 from the standpoint of the Plant Pathologist is simply the ever recurrent old one, that of keeping our aggressiveness and methods sufficiently up-to-date that favorable conditions for fungous diseases will not destroy our crops while we are patting ourselves on the back with satisfaction at the excellencies of our past results.

We do not know all that is to be learned with respect to a great number of fungous diseases. Furthermore, the practice of the horticulturists is not up to the highest standard of what we do know with respect to the real necessities, the real crises in application of sprays for the control of fungous diseases.

To revert to the apple scab problem, there are, with susceptible varieties of apples, two critical sprayings to be made each year with fungicides; viz, a thorough spraying just before the blossoms of the apple open, and a second thorough spraying immediately following the dropping of the blossoms of the apple—and in the latter spraying the Entomologist will tell you to apply your arsenicals for codling moth. Whatever other applications are to be made, these two are critical and their omission is fatal to the crop.

To this observation may be added another; viz., that improvement in fungicidal spray mixtures seems certainly possible. The indications are that Bordeaux mixture and Iron sticker with only two pounds of copper sulfate to 50 gallons of mixture and likewise the self-boiled lime-sulfur mixture of strength adapted to its purpose may be used on foliage of trees and plants properly with even better results than with standard Bordeaux mixture. These indications

are based on observations made on the apple, grape and potato. My advice to the Horticulturists of Ohio is to get ready to get out early and in timely periods spray thoroughly for the year 1909. We have had a season favorable to orchard fungi and they have shown us, as nothing else could show us, some of our orchard shortcomings.

FROM AN ENTOMOLOGICAL STANDPOINT.

THE RASPBERRY FLOWER BETTLE.

Byturus unicolor.

BY H. A. GOSSARD, ENTOMOLOGIST
Ohio Agricultural Experiment Station, Wooster, Ohio.

This insect has long been known to attack the raspberry, but, so far as known to me, has never hitherto been recorded as doing such severe damage as has occurred in an Ohio neighborhood for the past two years.

A grower of small fruits at North Olmsted, Cuyahoga county, reported in the summer of 1907 that he had harvested a crop of berries that season which brought him about \$160, whereas in ordinary years his income was about \$800 for the same patch. Specimens of the beetle proved it to belong to the same family as the Larder Beetle, and some of our museum pests. It is a very small, yellowish-brown beetle, about 1-6 inch long, covered with numerous fine hairs. The damage is done by the beetles feeding on the blossoms and leaves, and by the larvæ feeding on the berries. The bloom buds are just bursting, or are scarcely more than formed, when the beetles commence eating a hole through them, often devouring the stamens and the fleshy receptacle on which these stand. Later the worms are found feeding on the berries, between the fruit cap and the button.

In 1907, 90 percent of the berries in some vineyards at Olmsted were destroyed.

In May of the present season, we received a long distance telephone call, that the beetles were appearing in millions in the same vineyard that had been so badly attacked the preceding year. My assistant was at once dispatched to the scene of the trouble, and commenced spraying the following morning. Arsenate of lead was chiefly used, but kerosene emulsion was also tried, since it seemed necessary to kill a large fraction of the beetles outright, to prevent the destruction of the crop, before the poison could operate effectively.

The kerosene emulsion was only partially effective, but the arsenate of lead finally won the day. Although the spraying apparatus was poor, the final result was to secure about 70 to 80 percent of a crop, as against 10 percent the year before. As bad, or worse, results than 10 percent was realized this season in some adjacent vineyards that were badly attacked.

Although this outbreak was local in character, the beetle is known to be widely distributed over the United States and Canada, and in the future may attract more general attention than it has done in the past.

IN COMBATING FRUIT-TREE BARK BEETLES.

BY PROF. H. F. WILSON.

The Fruit-tree Bark Beetles have never been considered very serious. However, the conditions indicate that they are rapidly developing into dangerous pests, working more or less on all fruit trees—more especially on plum, peach, cherry and apple.

Until the last few years most of the beetle injury has been confined to wild trees such as wild cherry, ash, cedar, etc., only occasionally attacking orchard trees. At this time we find them pretty well spread throughout the orchard districts of Ohio, and doing considerable damage to both town and country property. Records from the cities of Cleveland, Sandusky, Toledo, Columbus, Dayton and Springfield, show that the beetles have become well established in all these districts.

Phloetribus liminaris and *Scolytus Rugulosus* are the worst of these pests. The greatest damage done by *P. liminaris* has been confined to Lakeside, Ohio, while the rest of the damage done is due to *S. Rugulosus*. Of late years the *P. luminaris* has done more damage in the locality of Lakeside than has the scale. The presence of the beetle is shown by numerous small strings of sap coming out of the abandoned burrows, and it is then too late to catch that brood. The trees attacked are mostly those weakened by some pests which have left the tree in a sickly condition. Settling upon a tree in this condition they will, in one season, completely kill it.

At other times, as are the conditions at Lakeside, the beetles become so abundant that many of them settle on apparently healthy trees. After boring in some distance, the beetles are driven away by the sap which pushes into and out of the borings thus made.

When a large number of beetles attack a healthy tree at the same time, the loss of the sap given off through these borings so weakens the tree that in several seasons the tree is unable withstand the beetles. They will reduce the bark to sawdust in a single season. In places large limbs will be completely girdled for six or more inches. Trees suffering from scale and root-borer are more liable to attack, as these pests weaken a tree very quickly when they get a start. Very little has been done with these beetles until the past season. The Government in cooperation with the Ohio Experiment Station, has, through the kindness of Mr. W. H. Wright, of Lakeside, Ohio, in giving his orchard for experimental purposes, succeeded in gathering considerable information on the life-history, habits and means of control of these pests.

The beetles are about 1-10 inch long, *S. Rugulosus* being slightly larger than *P. liminaris*. The most distinguishing character between the workings of the two is the brood-chambers. *S. Rugulosus* makes a brood chamber vertically, while *P. liminaris* forms the brood chamber horizontally with the limb.

Each brood-chamber will contain from 40 to 140 eggs and varies from $\frac{1}{2}$ inch to 2 inches in length. The *P. liminaris* comes out in the spring as the adult. The *S. Rugulosus* comes out as larva. The second brood of both comes out August 1st.

Of the 46 different experiments tried this season at Lakeside, seven or eight mixtures for application—all derived from two main products, whitewash and carbolineum avenarius gave very excellent results and seem to afford protection from these two pests.

The white-wash was tried mixed with several oils and also with substances to make it stick longer, the best of these being white-wash made with milk of any degree of freshness used in place of water to slake the lime. All the white washes tried, seem to keep the beetles from settling in the trees, without regard to these constituents. Carbolineum was, without a doubt, the best remedy, even a 20 percent solution being better than anything except white-wash. The surprising feature in connection with the use of this oil is that it can be applied to very young trees if treated when they are dormant, without sign of injury to the trees.

The fact that most of the trees attacked are those in a sickly condition, demonstrates that cultural methods can be made effective in fighting these insects. Manuring and fertilizing trees in a weak condition will undoubtedly aid the trees to drive off the beetles by forcing sap into the burrows. The destruction of all dead and nearly dead trees will go a long way towards keeping the beetles down. Do not allow piles of tree prunings to lie about the orchard, remaining the entire season as a harbor for all kinds of insects.

In treating the trees with white-wash, at least two treatments should be made—one at the beginning of the first brood, and the other at the beginning of the second; and should a third brood appear it will be necessary to treat for a third time. If some good “sticker” could be put into the white-wash so that it would stay on the entire season, these repeated applications could be omitted.

In the case of carbolineum, one good treatment per season will not only kill 95 percent of the beetles in the tree at the time of spraying, but will keep the beetles and other insects off for the rest of the season. The carbolineum appears to penetrate into the bark slightly and works right into the holes made by burrowing.

Two or more known parasites work on *S. Rugulosus*, each season causing the death of thousands of beetles. These attack the larva and when the time comes for the pupation of the larvæ we have a hymenopterous pupæ instead of a beetle pupæ. There are at least two generations of parasites and maybe three. So far as known, there are no parasites on *P. liminaris*. Nature’s means of handling such affairs will, as it has in other cases, undoubtedly bring them to a normal degree of development.

IN PACKING APPLES.

BY U. T. COX,

The results of the apple deal last winter demonstrated that proper packing of apples will pay. All kinds, good and poor, were dumped into barrels and put on the market at high prices; but the buyers became disgusted when they reached down near the center of the barrels and found anything but good fruit; and as it cost them so much, they did not care to buy more. Then the market went down for want of buyers.

If there had been good fruit packed there would have been buyers and it would have brought better prices last spring than it did. The growers were not the only ones to blame, for many buyers bought orchards and packed the fruit themselves, taking everything on the trees.

I venture the assertion that buyers, and also growers, will not pack all the culls in the middles of the barrels this year. They will grade them, putting each grade in a package by itself. The packages should be marked so the buyer may know what variety and grade he is getting; and the face should be a fair representation of what is in the middle of the package.

The grower or packer should have his name and address on every package as a means of advertising or identification. Growers should learn to pack their own fruit, as they can do it cheaper than the buyer, as he must bring high-priced men with him and pay their expenses.

IN ORCHARD PLANTING.

BY C. W. WAID.

The planting at our place last spring consisted of about 2,500 fruit trees, four-fifths of which were apple. Three-fourths of these were secured from a nursery in which the San Jose scale was present in limited numbers, hence the state laws required the trees to be fumigated before they could be sold. As the season was very backward, it being so wet that little could be done in the way of working the soil until after the time for tree planting had come, the trees had started considerably before they were dug. At the time the fumigation was given, the buds were swollen to such an extent that the color showed on many of them. When the trees were delivered, the effect of the fumigation on the buds was apparent, as those which showed color had begun to turn brown. I noted this fact at the time, but thinking that it would simply retard the growth of the trees somewhat and not seriously damage them, I gave the matter little thought. The trees were set when the soil was in good condition and with considerable care. There was a sufficient amount of rainfall during the fore part of the season to insure a good growth of the trees. I noticed, however, that the fumigated trees were very slow to leaf out. I did not, even then, feel much concerned about them, as I thought they would come out all right in time. As the season advanced and most of the fumigated trees failed to make satisfactory growth and some of them began to die, I investigated to see if I could find what the cause might be. A careful comparison between the trees that had been fumigated and those which had not, showed that the latter had made much the better growth. As the trees which were not fumigated were not purchased from the same party as those which were fumigated, the solution of the problem was still in doubt.

The State Inspector, who conducted the fumigation of the trees which we received last spring, said that he was not surprised that they did not grow well as they were handled so carelessly. I knew that the trees were hauled some 12 or 15 miles on a bright day without any attempt being made to protect the roots; but as we received trees

of the same party the year before which were handled the same way both as to the manner of fumigating and hauling, and the trees grew well that season, I could not come to any other conclusion than that the fumigation injured the trees.

I know that I am passing judgment with only a limited experience along this line; but I have heard others say that they consider the fumigation of nursery stock a dangerous thing and liable to cause injury. One party said that he had known of instances where small-fruit plants were injured by the gas; another man said he would rather have trees for planting, the bodies of which had been dipped in a lime and sulfur solution, than those which had been fumigated, even though the lime and sulfur treatment is not as sure, because he thought it safer. I have used hydrocyanic acid gas in the greenhouse quite frequently and know that it is a very delicate matter to do effective fumigating with growing plants without injuring them. Does it not naturally follow that plants which are not perfectly dormant may be subject to the same kind of injury with the same kind of treatment?

In conclusion may I repeat that, judging from our rather limited experience, there seems to me to be danger of injury to nursery stock by fumigating with hydrocyanic acid gas, at least when the stock is not perfectly dormant. We have a law in Ohio, which compels, under certain circumstances, the use of this gas on nursery stock. If there is danger of serious injury from the use of this gas, is it not rather inconsistent to compel its use? I am willing, and will be glad to be convinced, that the proper use of this gas is not injurious to nursery stock; but I feel that this is a matter which needs careful and thorough investigation.

IN ORCHARD SPRAYING.

BY M. I. SHIVELY.

I have had very satisfactory results, this year, from spraying before the opening of the apple buds. In almost every case in this section, the fruit is almost free from scab where spraying was done before the buds opened, while, on the other hand, where spraying was delayed until after the buds opened, the fruit is badly scabbed. I have great faith in early spraying with double strength Bordeaux mixture while the buds are yet dormant.

In my home orchard this year, I have the finest crop of perfect apples I have ever grown, while on neighbors' orchards where spraying was not so thoroughly done, the scab rendered the apples almost worthless. I marketed 1,338 bushels of the finest Yellow Transparent ever grown here, from 262 trees.

HOME PROPAGATION OF FLOWERING SHRUBS.

BY W. E. BONTRAGER.

If home owners knew how inexpensively their lawns might be improved there would be fewer bare, unsightly yards to be seen throughout our state. With little trouble and the expenditure of only a few days' work in each year the boys and girls can adorn the home with clambering vines and beautiful trees and shrubs. Many kinds of desirable trees and shrubs can readily be propagated by means of cuttings; and all kinds of vines can be increased in this manner or by the equally simple process of germinating seed.

An instance is known of an enterprising young home-improver who has grounds considerably more than an acre in extent, improved with a varied and extensive collection of shrubbery, nearly all of which is the product of a small number of stock plants procured at a cost of a few dollars. Planting material which would have cost a hundred times as much if purchased at a nursery has been produced at a surprisingly small outlay. Outside of the saving, there is a delight in growing one's own shrubbery, and, should it be desirable, the practice can be made to yield no small revenue, even in the most isolated rural community. By employing the simple expedient of propagating from hardwood cuttings, a single specimen of spirea Van Houttei, or golden elder, or panicle dogwood may yield in a single season from half a dozen to a score of thrifty, well-rooted little plants—sufficient for the formation of one or more pretentious clumps that will soon become the envy of the entire neighborhood.

The method is so simple as scarcely to merit description, yet perhaps a few words concerning it may not be amiss: In October wood of the current season's growth should be cut into sections eight or ten inches in length, neatly and securely tied in bundles of twenty-five to fifty and buried in a narrow trench in a well-drained corner of the garden plot. These bundles should be covered with earth to a depth of from three to six inches, and the warmth afforded by a mulching of straw or coarse manure will be beneficial. As early in the spring as the ground is at all fit to work the cuttings should be removed from the trench and planted a few inches apart in rows eighteen to twenty inches distant from each other. Zealous attention to the details of weeding and hoeing should induce a vigorous growth and at the end of the first season the cultivator will be rewarded with thrifty, vigorous, well rooted stock. In the Experiment Station's nursery are now growing plants of Japan quince, red-twigged dogwood, bush honeysuckle, several kinds of spirea, Amoor privet and forsythia, all from cuttings taken last October, and doubtless many other kinds will respond equally well to this method of treatment.

REPORT OF THE COMMITTEE TO EXAMINE FRUIT.

Mr. R. A. Hunt exhibited three varieties of plums to be named. One of Gage type, larger than Imperial Gage, of excellent quality; one much like Geuii; another of German Prune type. Committee cannot name any of them.

Mr. S. C. Maxwell, Piqua, Ohio, R. D. No. 6, exhibited a fine white apple of large size, good general appearance and of good quality. Season, last of August. Committee cannot name.

Mr. C. W. Fleming, Frazeysburg, Ohio, exhibited a seedling white peach of good size and color, not ripe enough to tell quality; much like Champion but later in season. Mr. Fleming also exhibited a peach thought to be Globe. Committees think it is not globe but is unable to name it.

Messrs. Withoft and Bassett, Dayton, Ohio, exhibited a peach named "Queen." Size, very large, yellow flesh, good in appearance, quite astringent; much like Globe.

Mr. Seymour Norton, North Amherst, Ohio, exhibited a basket of apples of very attractive appearance, fair size; quality said to be good especially for culinary purposes. Seems worthy of trial by other growers. Name of variety not known.

Mr. M. M. Miesse, Lancaster, Ohio, exhibited a basket of musk melons—a chance seedling, said to be a cross between Tip Top and Rocky Ford. Of good quality and worthy.

S. R. Moore } Committee.
C. W. Waid }



Field demonstration with potato diggers.

POTATO GROWERS' MEETING
of the
OHIO STATE HORTICULTURAL SOCIETY

Held at Tiffin, Ohio, October 16, 1908.

POTATO GROWERS' FIELD MEETING.

A special potato growers' field meeting was held, under the auspices of the Ohio State Horticultural Society, on the farm of Mr. Dan Egbert, near Tiffin, October 16, 1908.

This was one of the most successful meetings of the season. Fully five hundred persons were in attendance—a number coming a hundred miles or more. Not a few visitors came from the cities of Tiffin, Fremont, Cleveland and Toledo.

Mr. Egbert is one of the Experiment Station's valued cooperators who is carrying the lines of corn and potato breeding and experiments in the fertilization of these crops, as well as the growing of alfalfa. He exhibited at this meeting an extensive collection of "hill-row" products of potatoes from hill selection work; also the various products obtained from the use of different quantities and combinations of fertilizers on his potato ground. The different lots were all shown in crates with explanatory labels.

An especially attractive feature was a field demonstration with different potato diggers. This interesting exhibit was given by various firms which build potato digging machinery. Five firms were represented in this demonstration which was not, in any sense of the word a contest. No premiums were offered, nor was any committee appointed to determine which of the machines did the best work. All worked well under the favorable soil conditions existing at that time, and the great company of visitors which followed the diggers back and forth across the great potato field, was allowed to draw its own conclusions.

The diggers shown in operation were the "Hoover," the "Iron Age," the "Champion," the "Dowden" and the "Planet Jr."



An interested company of Ohio horticulturists.
The potato field in the background.

VARIETIES OF POTATOES.

BY DAN EGBERT.

This first number on the program is not supposed to be an essay or paper on potatoes in general. We do not care to go into the history or botany of the plant; we only wish to give you a few notes on varieties grown on this farm within the last seven or eight years. Up till the last three years the impressions gained of the different varieties must be recorded from memory, but some years ago we started to make comparative tests of varieties, some under direction of the Ohio Experiment Station and some were of varieties new and old grown in this neighborhood; but all with the primary object of finding about three varieties that came nearest our idea of potatoes for the three different purposes and seasons. For a first early we would be willing to sacrifice prolificacy and size for earliness and quality; for a medium season we would want a good yielder of good quality (might tolerate red color in a medium season potato); for a general crop or late potato which at the present state of the market, might be indifferent in quality, we would want a round, white, smooth and a satisfactory producer of good crops of marketable tubers.

The first test three years ago, was of some 11 or 12 varieties procured from neighbors, planted only 110 hills to a variety, and thinned down to 100 hills each, after danger of destroying hills in cultivating was nearly past.

I remember Maggie Murphy led all the rest, but its color wouldn't do for a late potato; too deep eyed, and liable to get hollow also. Then came Gold Coin, a close second in point of yield, but very scabby; then Sir Walter Raleigh which surpassed slightly the Carman No. 3, and Mills Prize—other representatives of the Rural. Carman No. 1 and Green Mountain gave good yields, but, like their relative Gold Coin, were scabby and inclined to be rough and spongy, and so on down the list till we come to the last two, the Blue Neshannick and Peachblow, of revered memory. A test of this kind, while not being very conclusive the first year, is quite interesting and, if carried on for a term of years, would be of considerable value to the grower and can be done with very little extra work.

The next year, 1907, we undertook a larger test of varieties under the direction of the Ohio Experiment Station. We had in this test 23 varieties, one-tenth of an acre each. The following varieties were classed as early: Noroton Beauty, Early Bird, Early Petoskey, Algoma, Sensation, Early Monarch, Morning Star, Early Standard, Early Toledo Market, Early Michigan and Irish Cobbler.

The later ones were: Carman No. 3, Ionia Seedling, Money-maker, Lily White, President Roosevelt, Happy Medium, May's Late, Washington, Spaulding No. 4, Stump the World*, Prosperity and Reliance. In addition to these we put in one-tenth acre each of the two main crop varieties we had been growing on the farm, Sir Walter Raleigh and Gold Coin.

We might sum up briefly by comparing some of the newer varieties with some of our well known sorts. Prosperity is quite like Sir Walter Raleigh. President Roosevelt is quite like Rural. May's Late resembles Michigan Russet and Rustycoat. Washington is somewhat like Gold Coin and Green Mountain. The varieties planted this year were grown more with idea of propagating the best looking varieties of last year's test than with the idea of comparing yields. We planted all the seed we had but have not figured out for this year the yield per acre, but the indications are that the yields are quite similar to the results of last year with the exception of Stump the World, which is not nearly so good.

POTATO SEED SELECTION AND IMPROVEMENT.

BY F. H. BALLOU.

In no other single species of the many families of plants propagated by buds, scions, cuttings or divisions of roots or tubers, do we find in cultivation a subject of greater promise or possibilities in improvement by selection of seed stock, than the potato. It is well to bear in mind, however, that where possibility of improvement exists in so great a degree there necessarily exists an equal possibility of deterioration. This fact, in itself, accounts for the well-known truth that there are growers who, when they find a variety which succeeds well on their particular soil, retain that variety year after year; and that year by year said variety improves in those qualities which are particularly sought by the planter. Likewise is accounted for the truth that others find a variety which at first succeeds admirably with them, but which, after a series of less and less satisfactory returns, is finally reported as having "run out." These different results, directly opposed in character, can usually be traced back to, first, natural variation of plants of the same variety and, second, the disposition of the grower to take advantage of these, or his error in by following a practice which results in these same variations bringing him face to face with discouragement and financial loss.

* NOTE—Stump the World is one of the latest maturing varieties in the entire collection grown by Mr. Egbert. As the latter part of the growing season of 1908 was marked by one of the severest droughts experienced for many years, this late variety suffered most severely. Stump the World is, in normal seasons, one of the most vigorous, growy, healthy and productive sorts under test at the Experiment Station.—F. H. B.

Progress can be made in improvement of potato seed stock by the selection, from bin or bulk, of well-formed, smooth, uniform tubers which are as nearly true to type of the variety as possible. This will at least suffice for a starting point in improvement, providing the initiative has not been taken until after it is too late to select from individual hills in the field. But the tubers thus chosen will probably be representative of high, moderate and low yielding strains. There is absolutely no way of distinguishing, in the bin or bulk, between a large tuber which was one of several similar ones in a high yielding hill, and a large tuber which was the only one of marketable size in the hill. But let us, by all means, make a start by selecting these representative tubers which will be of sufficient size that a uniform number of good sized and uniform seed-pieces containing single eyes, may be cut from each one. As in all test work, this selected stock should be planted on as nearly uniform soil as can be chosen. The seed-pieces from each individual tuber should occupy a separate, short row and each row marked by a numbered stake driven securely in the ground. It is desirable to use the same number of seed-pieces in each short row, and these rows are better planted side by side or in as compact a block as possible. The test can be made in any part of a field of potatoes providing the test rows be grouped compactly and labelled substantially. Fertilization and cultivation should be uniform with that of the general field or area. The greater the number of tuber-rows used, the greater will be the opportunity not only for observation of the many variations which are sure to be exhibited, but for selection of the more promising strains at the time of harvesting. These tuber-test-rows must be dug by hand so that no mixture or confusion may occur. The product of each may be weighed and its weight recorded, if the different lots are to be tested on a larger scale the next season. Or, if but this one season's test be all that the grower desires to make, weigh out or select the product of those tuber-rows which gave the highest yield of fine, marketable tubers. These different lots may then be thrown together and the composite seed stock thus secured used in field work the following year in comparison with the common or unselected stock. A single season's selection in this manner has, in definite cases, been the means of increasing the yielding power of the variety from 25 to 33 percent; and while the good effects of such a selection are likely to be apparent for some seasons to come, the plan of testing out the higher yielding strains should be continued for two or more seasons.

Another simple plan for potato seed improvement—one still more easily accomplished and likely, therefore, to appeal to the busy farmer, is to dig a block of potatoes by hand, in a representative

section of the field or plot, throwing each hill by itself as dug. When several hundreds, or as many hills as it be desired to dig are thus exposed, careful selection of the more prolific hills of smooth, good sized, marketable tubers is made. These selected hills may either be thrown together and planted the next season in the usual way, or kept separate and a *hill-row* test made just as has been described for a tuber-row trial. This is for the purpose of proving out that which seemed apparent in the original selection; for the effect of special environment must be taken into consideration. A hill of potatoes may be good because it is inherently good even under unfavorable conditions; or it may be as good or better than adjoining hills because of unusually excellent conditions which it alone enjoys. It is for the purpose of eliminating the results of environment and determining the characteristics which are hereditary or actually developed through natural plant variation, that the tuber-row and hill-row tests are recommended to be continued two or more seasons. Careful work along these lines includes not only repetition of these tests for several seasons with the same strains, but duplication in each separate season, or the division of the hill-row or tuber-row in such a way that one-half will be situated in one section of the test plot and one-half in another section.

Some experimental work has been done in selecting potato seed stock by taking the product of those individual plants which are apparently resistant to fungous disease—those which stand up longest and grow latest in the field. Good results have been achieved by this plan of selection, though not better than by selecting for actual results in tuber development within the hill. Unless disease be really present in the field and is responsible for a general, premature breaking down of the plants, there is danger that, by selecting from these long-living, late-growing plants that we are propagating strains that are tending, through natural, slight variation from the original, toward a later date of maturity rather than special disease resistance. It is a common thing, moreover, to find, upon maturity of these late growing plants, that the actual product in the hill is less than in nearby individual hills the plants of which matured naturally or without disease, a week or a month previous. It is the actual work done by the plant within the hill in which we should be more interested; and such results are those which should cause us to choose or reject a hill when we are making our selection. I wish to emphasize the fact that, while there are disease resistant or "blight resistant" strains of potatoes as shown by careful experiment, selection for disease resistance is only practical or sensible when disease is actually present in the field.

The question is often asked: "What about using the small potatoes for seed?" This has sometimes been answered by those who do not favor the plan, that it would be just as reasonable to inquire "what about using the 'nubbins' of corn for seed?" Others who favor the use of small seed tubers contend that so long as the stock is "pure" it is just as good for planting as selected tubers of marketable size. I believe each class of disagreeing growers is right in part and mistaken in part. Let us endeavor to analyze the question in the simplest, common-sense way, keeping in mind the truths we have been considering regarding the variation of plants—the tendency of certain plants to advance above or fall below the average of their kind. Suppose there is, from which to select the seed, a small plot of potatoes containing 1000 hills. These are common or unselected stock containing, as average stock invariably does, unknown percentages of high-, moderate- and low-yielding strains. Let us suppose that 800 of these hills fairly represent the average of the variety. Possibly 50 hills, were a test conducted to separate them, would prove to be superior to the average. Possibly 150 hills in the same test would show an inferiority to the average; for the tendency toward a falling below or deterioration usually appears to have been greater than the tendency toward advancing above the average when common stock is first taken in hand for trial. These inferior, low-yielding hills will be composed, it is evident, of a very heavy percentage of small, inferior, unmarketable tubers.

Now what would be the character of the seed tubers chosen by the grower who insists upon using first-class seed stock. He would accept only smooth, uniform potatoes of marketable size. These would necessarily include a *very heavy* percentage of the high-yielding type; a *heavy* percentage of the average type; a very insignificant percentage of the inferior type, including only the occasional tuber or tubers that would grade up to the desired size. From this character of seed would not his chances for deteriorating his stock be very small?

Upon the other hand let us see what is the character of stock the grower is likely to include, who insists upon selling the marketable and planting the small tubers. He would get from the high-yielding sort a *very small* percentage; a *moderate* percentage of the average type and an *extremely high* percentage of the inferior type. In other words, when the grower plants the small tubers culled from his general crop of potatoes his seed stock practically contains but a small percentage of those strains which produced his marketable product, and almost the total percentage of the product of the hills

that contained the small, inferior, unmarketable tubers. In this way, year by year, the proportion of the seed stock emanating from hills of unmarketable potatoes becomes larger and larger. The standard of his stock, as a whole, as a matter of course, gradually lowers correspondingly—annually dropping from the average to the inferior types. The inevitable result is that it is only a matter of time until we are met with his argument that varieties “run out” in support of which he offers his crop as evidence that he is correct.

There is always evidence forthcoming than there have been most excellent crops of potatoes grown from certain lots of very small and unpromising seed stock. We have grown them and have observed them and have heard of them without number; but the truth remains the same: The final results of persisting in planting poor seed stock will be the same as those sure to be attained sooner or later in breeding any other kind of scrub stock.

There are, however, conditions under which it is safe, for a time, to use small potatoes for seed. It is after a course of thorough work in selecting and testing out the more excellent strains of the variety with which we are experimenting. The small tubers of these improved strains are, for a time at least, and for the most part, small because of environment and conditions of soil or crowding in the hill and not because of direct inheritance of low vigor and inferiority. But at the same time of using such stock there should be in progress a continuance of selection work the basis of which is selected hills from the original carefully selected strains.

Much more might be added in discussion of this subject which is certainly one of utmost importance to potato growers. But I trust this is sufficiently clear and sound as to prepare and encourage us to become, in the future, closer observers of that which is taking place all about us—in garden, orchard and forest—and to enable us to take advantage of these variations in plants, especially in the improvement of the seed stock of a crop which now ranks fourth in the number of bushels annually produced from Ohio soils.

In the general discussion which followed the presentation of the foregoing papers an important point concerning seed potatoes was brought out. In reply to a question “is northern grown potato seed stock preferable to that grown here in Ohio,” Prof. W. J. Green stated that it is more a matter of *condition* of the seed tubers at the time of planting than where such seed may have been grown. Hard, sound, dormant seed stock is decidedly superior to that which has become sprouted and withered in a storage cellar of too high a

temperature. Conditions as relating to temperature are favorable in the more northern latitudes for the preservation of seed stock in the best possible condition. Such seed comes down to the more southern planter sound and dormant, while our own imperfectly preserved stock is wasting its vitality in premature sprouting in too warm storage rooms. Northern grown seed under these circumstances is preferable; but dormant, hard, crisp seed of our own growing and keeping is just as good as the northern grown product. This was clearly demonstrated in a test at the Experiment Station in 1906, as well as at various other times.

Prof. Green also stated that it is an excellent plan to grow seed stock by late planting of seed tubers which have been for several weeks spread in thin layers on out-door shelves and sprouted in direct sunshine. Short, green, firm sprouts of pencil-point form are developed in this way. By careful handling these tubers may be cut and planted without injuring the sprouts—even when a horse planter is used.

This is a popular practice in the south where the earlier crop of tubers, on account of the high temperature of that latitude, cannot be preserved for the next season's planting. And it is in the south that, for this reason, northern grown seed is generally superior to the home grown product. The "second crop seed," however, keeps in a fairly sound condition even in that latitude, and gives excellent results. The late planting may be done on ground which has produced an early maturing crop of vegetables or strawberries.

Mr. W. W. Farnsworth stated that it was his plan to plow under his old beds of strawberries in July and follow with a late planting of potatoes, using sun-sprouted, whole seed tubers of a size intermediate between the marketable grade and the culls. He prefers whole tubers on account of their comparative immunity from rotting in the soil should weather conditions favor such loss.

573c
P. 1 Page

Ohio Agricultural Experiment Station.

CIRCULAR No. 90.

WOOSTER, OHIO, MARCH 1, 1909.

SEASONAL REPORT OF POTATOES—1908.

The past season was not favorable to the growth of potatoes owing to the small amount of rainfall.

Some observations of results for the season of 1908 in potato work and deductions therefrom, based on notes taken at the Experiment Station and reports received by the Cooperative department from several hundred farmers representing every county in the state, are embodied in this circular. Conditions affecting the growing of potatoes vary markedly in different localities and from one season to another in any given locality, so that the results herein given are not stated as factors constant for the varieties in all places nor for all seasons, but simply as recorded by different growers over the state for the past season.

Such a dry season as we have just experienced tests farmers' practice of tillage to the utmost. Some men have reported complete failure in their experiments, owing to the drought, while in most cases special mention was made of the poor season.

When we consider the regularity in the behavior of many varieties on many types of soil, under varying moisture and plant food conditions it becomes evident that we can assume with a fair degree of accuracy varietal descriptions.

The following list of varieties is given which were on trial the past season, the data mostly based upon the reports received from cooperators.

REPORT OF POTATO VARIETY TEST—1908.

Make all records at time of observation—Do not trust to memory. Use additional blanks if more than five varieties are tested.

* Variety	Date of plant- ing	* No. hills per row at plant- ing.	* No. hills per row at dig- ing	Date of matur- ing	* Yield market- able potatoes lbs.	* Yield un- market- able potatoes lbs.	* Date of appear- ance of blight	* † Kind of blight { early } { late }	Dam- age by cent of blight	Per cent of scab	Cooking qualities { good } { fair } { poor }	Market- able qualities { good } { fair } { poor }	* Nature and depth of soil	* Nature of sub-soil	Pre- vious crop	Man- ure or Com- ferti- lizer
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

* These columns are of special importance † See O. A. E. S. soil circular No. 39 which will be sent upon request. ‡ Send specimen leaves for determination

How many acres do you usually devote to the potato crop..... What was your field average this year?.....

What varieties of potatoes are grown in your neighborhood?.....

Have you ever sprayed your potatoes?..... If so, with what results?.....

On the reverse side of this sheet make an accurate map of your plots showing each variety in its proper place and in connection therewith the surrounding farm crops. Give a brief description of your method of handling the soil for this crop and note any unusual conditions; insect, storm or other damage; facts regard- ing rainfall and temperature, also suggestions regarding tests.

Name..... P. O..... Date of mailing.....

My farm is located in..... Township..... County.....

Where the records are doubtful or nil the space is left open or marked indeterminate. In other cases the data are given as received but may be somewhat misleading, i. e. some of the early varieties are marked low in yield but it must be remembered that they are low in comparison with some later varieties while compared with early sorts they might rank high. The matter of cooking quality is largely one of personal taste or preference, and in this case the prevailing number of answers generally decided whether it be very good, good, fair, poor or very poor. The same method was used with most items and the same modifying words used. There were a number of other varieties sent out for trial but not enough to give any satisfactory data.

Mention is made in a few instances of tendency to blight and scab. This is quite a variable factor and is only given where it was specially noticeable.

The report sheet used by the Cooperative department for potatoes is appended.

In addition to these variety tests the Experiment Station is also prepared to assist cooperators in making fertilizer and breeding tests.

VARIETIES OF POTATOES TESTED IN 1908.

Variety	Season	Yield	Cooking qualities	Marketable qualities	Color and skin	Shape	Resistance to blight	Resistance to scab
Algoma	.....	.....	.....	.....	.....	.....	.....	.....
A. M. Giant	.....	.....	.....	.....	.....	.....	.....	.....
*Banner	Late	Medium to high	Good	Good	White with some russet	Variable, somewhat flattened	Resistant	Quite scab.
Bovee	Late	Indeterminate	.....	Fair	Yellowish white, smooth	Long, cylindrical	Resistant	by.
Cal. Russet	Early	Medium to high	Good	Good	White often pink tint	Oval, somewhat flattened	Resistant	Resistant.
Carman No. 3	Late	Medium to low	Good	Fair	Yellowish white, russeted	Short, cylindrical	Resistant	Resistant.
Clyde	.....	High	Fair	Very good	White, smooth	.....	.....	.....
D. J. Miller	.....	Medium	.....	Fair	White, some russet	Oval, flattened	Resistant	Resistant.
Early Bird	Medium	Indeterminate	.....	Fair	Brownish white, some russet	Round	Resistant	Resistant.
" Breakfast	Medium Early	Very high	Good	Good	Yellowish white, lightly netted	Variable, rough cylindrical	Resistant	Resistant.
" Fortune	Early	Very low	Good	Poor	White, netted	Oval to long	Non-resist	Non-resist
" Johnson	.....	High	Good	Good	Pink, smooth	Variable, round to oblong	Non-resist	Non-resist
" Michigan	.....	High	Good	Fair	White	Round to oval	Non-resist	Non-resist
" Monarch	Early	Medium	Good	Good	White with pink tint	Oval to oblong, flattened	Non-resist	Non-resist
* Ohio	Very Early	Medium	Good	Good	Light pink	Roundish, oval	Non-resist	Non-resist
* Petosky	Early	Very Low	Good	Good	White, smooth	Nearly round	Non-resist	Non-resist
* Rose	Medium Early	Medium to low	Good	Good	Rose, smooth	Round	Non-resist	Non-resist
" Standard	Early	Very low	Good	Good	White, russeted slightly	Cylindrical	Non-resist	Non-resist
" Sunrise	Medium	Very low	Good	Fair	Yellowish white, russeted	Rather oblong, variable	Non-resist	Non-resist
Frayer's O. K.	.....	Low	.....	Fair	Reddish w'te, red eye, some russet	Roundish	Non-resist	Non-resist
Green's No. 21	.....	Medium to low	Good	Good	White, smooth, some russet	Flattened, oblong, oval	Resistant	Resistant
Green Mountain	Late	High	Good	Good	White, some russet	Round, flattened	Non-resist	Non-resist
Happy Medium	Late	Low	Good	Good	Yellowish white	Oval, flattened	Resistant	Resistant
Harold's Choice	Late	Very high	Good	Good	White, smooth, some russet	Roundish, oblong flattened	Non-resist	Non-resist
H. Y. Carman No. 3	Late	Very high	Good	Good	White, smooth	Oval, flattened	Non-resist	Non-resist
Ionia Seedling	Late	Medium to low	Fair	Good	Yellowish white	Oval, flattened	Resistant	Resistant
Irish Cobbler	Early	Medium to very low	Good	Good	White	Flattened, often tapering	Non-resist	Non-resist
Johnson's No. 1	.....	Indeterminate	.....	Poor	White, netted	Short, oval, slightly flattened	Non-resist	Non-resist
Johnson's No. 2	Late	Medium	.....	Good	White, slight russet	Round	Partially resistant	Non-resist.
Keller's Gr'n M'tain	Late	Medium to high	Good	Good	White, netted	Oval, flattened	Partially resistant	Non-resist.
Lepas	Late	High	Good	Good	White, slightly netted	Round, oval inclined to be flat	Resistant	Resistant.
Lily White	Late	Medium to high	Good	Good	White, netted	Roundish, oblong	Non-resist.	Non-resist.
Livingston	Late	Very high	Good	Good	White, pink eyes, some russet	Medium to long, tapering	Non-resist.	Non-resist.
Market Prize	.....	Low	Good	Fair	White, slightly rough	Short, oval, flattened	Non-resist.	Non-resist.
May's Late	Late	Very low	Fair	Fair	White, netted	Roundish, oval often tapering	Non-resist.	Non-resist.
Merrill	Late	Indeterminate	.....	Fair	White, slightly netted	Cylindrical, round to long	Non-resist.	Non-resist.
Miller-Brooke	Late	Low	Good	Fair	Pinkish brown, netted	Cylindrical	Non-resist.	Non-resist.
Money Maker	Medium	Very low	Good	Fair	Yellowish white, russeted	Tapering, flattened	Non-resist.	Non-resist.
Morning Star	Late	Medium to low	Good	Fair	Yellowish white, russeted some	Medium to long, flattened	Non-resist.	Non-resist.

*No seed of these varieties available.

VARIETIES OF POTATOES TESTED IN 1908. Continued.

Variety	Season	Yield	Cooking qualities	Marketable qualities	Color and skin	Shape	Resistance to blight	Resistance to scab
*New Snow.....	.....	Very Low	.....	Good	White, netted	Roundish, flattened		
Noroton Beauty.....	Extra Early	Very Low	Good	Fair	White, pink markings and eyes	Short, roundish	Non-resist.	Affected
Noxall.....	Late	.....	.....	Good	White, flaky	Oval, flattened		Affected
Ohio Wonder.....	Late	High to very high	.....	Good	White, lightly netted	Roundish, flattened		
President Roosevelt...	Late	Medium	Good	Fair to good	White, netted	Roundish oval, flattened	Resistant	
Prosperity.....	Late	Medium to high	Good	Good	White, some russet	Roundish oval, flattened	Fairly resistant	
Pioneer.....	.....	High	.....	Fair	White, smooth	Long, cylindrical		
Reliance.....	Late	Low	Good	Fair	White with pink tint, netted	Roundish, flattened		
*Rural New Yorker...	.....	Low	.....	Poor	Pinkish tint, slightly netted	Oblong oval, somewhat flattened		
Richmond.....	Late	High	Good	Good	White, smooth	Oval, flattened		
Rural Russet.....	Late	Medium to high	Good	.....	Brownish white, russeted	Flat oval		
*S. Com. Violet.....	Late	Low	Very Good	Good	Red, smooth	Long, oblong to cylindrical	Resistant	
Sensation.....	Early	Medium	Fair	Fair	Purplish red, smooth	Long, cylindrical, short		
Spaulding No. 4.....	Medium Early	Low to Medium	Good	Fair	White, pink tint, smooth	Long, cylindrical, variable		
Stamp of the World...	Very Late	Medium to high	Good	Fair	Light pink	Roundish, somewhat flattened	Resistant	
Star of the East.....	Medium	Low	.....	Fair	White	Roundish, flattened		
Toledo Market.....	Early	Medium	Good	Fair	White, smooth	Long, cylindrical		
V. Gold Coin.....	Late	High	Very Good	Good	Pink, smooth	Oblong, cylindrical		
Washington.....	Medium Late	Low	Good	Good	White, russeted	Roundish oblong, flattened		
White Albion.....	.....	Medium to low	.....	Good	White, smooth	Medium to long, slightly flat		
W. W. Mammoth.....	Medium Late	High	Good	Good	Yellowish brown, smooth	Oval, often flattened		
					White, netted	Oval to long, flattened		

*No seed of these varieties available.

The accompanying curves show the behavior of varieties under varying conditions. In all cases a duplicate row of each variety was planted as a check. The curves graphically explain the yields although exact figures are not given. If the curve goes up the yield was high, and if it goes down the yield was low. The figures to the left of the curves represent pounds per row. The length of the rows at the Station were much longer than they were in the co-operators' tests, which explains the higher figures in the curves from the Station.

The solid line represents one row of the variety and the broken line a duplicate row. These curves do not show just which varieties may be depended upon to give the highest yields, but rather the variation in yield of some of the most reliable sorts, under diverse conditions, is not so great as to preclude the possibility of determining very closely their relative standing as to productiveness.

The work of hill selection of seed potatoes as reported in Bulletin 174 of this Station has been continued and also the work on blight-resistant strains of potatoes.

The object of the plant breeder is to determine the best plants in a variety and select seed from them, cultivate them under favorable conditions and thus perpetuate the desirable qualities and characters.

In the work carried on at this Station and reported in Bulletin 174, the variety Carman No. 3 was selected for high yielding. The hills were dug by hand and the hills yielding the largest number of marketable potatoes were selected, and also those yielding the smallest number. These were called high and low yielders and saved for seed. At planting time an equal number of hills were planted and cared for under the same conditions and in addition an equal number of hills were planted from seed which was not selected, but taken from the barrel or bin in the ordinary way of selecting seed. The results have been published and showed undisputed results of the selections. After five years' selection, a strain of high-yielding potatoes has been secured which is plainly superior to unselected stock.

The results of 1908 are given below and also a comparative form in the chart of curves in this circular:

Variety	Row	Good	Small	Bushels per acre
High-yielding Carman No. 3.....	1	163½	38½	234.8
	2	142	31½	
Low-yielding Carman No. 3.....	1	44	31	125.1
	2	72	29½	
Common Carman No. 3.....	1	110	52	137.4
	2	114	50½	

This seems to be conclusive evidence that selection pays. According to these figures the increase due to selection was about 41 percent which at present prices gave an added value per acre of more than \$68.00.

The method of procedure by which a variety of potatoes is improved is very simple and easily carried out by any careful grower. When the crop is dug the most prolific hills may be selected and kept separate for a comparative test the following season. In this manner a prolific strain may be started. Something may undoubtedly be gained by throwing the product of the most prolific hills together, but this method is open to the objection that the highest yielding hills do not always give the best yielding strains. Where machinery is used in digging it will be necessary to go ahead of the digger in making selections.

Bolley* states that in planting equal weight pieces from small and large tubers, there will not be a sufficient difference in favor of the one or the other size of potatoes to be noticeable under farm methods, provided all are normally matured. This shows that selection from a bin will not necessarily do anything toward improving the crop.

Another line of work on the potato that is of value, if adopted by the grower, is the increased yield which may be secured by selecting blight resistant strains of varieties. A fact which is familiar to every grower of potatoes is that some varieties are much less subject to blight and disease than others and some of the hills of these varieties are more immune than others. W. W. Mammoth was chosen for work along this line and an increase in large potatoes of 40 percent and a total yield of 25 percent was secured. This was attributed to a longer period of growth. This season there was but little blight and practically no difference in yield as shown in the table and curves. However, as the matter stands at present, it appears that if we select the highest yielding hills without much regard to blight we will secure better results than if blight resistance alone is considered.

Variety	Row	Good	Small	Bushels per acre
W. W. Mammoth (Blight resistant).....	1	95	26.0	182.9
	2	121	31.5	
	3	119	31.0	
	4	120	33.0	
W. W. Mammoth (Blighting strain).....	1	130	24.0	159.9
	2	110	26.0	

*N. Dak. Agr. Exp. Sta. Bul, 130, pp. 210-243: 1897.

CHART I—Comparative yields of varieties of potatoes grown at Experiment Station on silt loam soil.

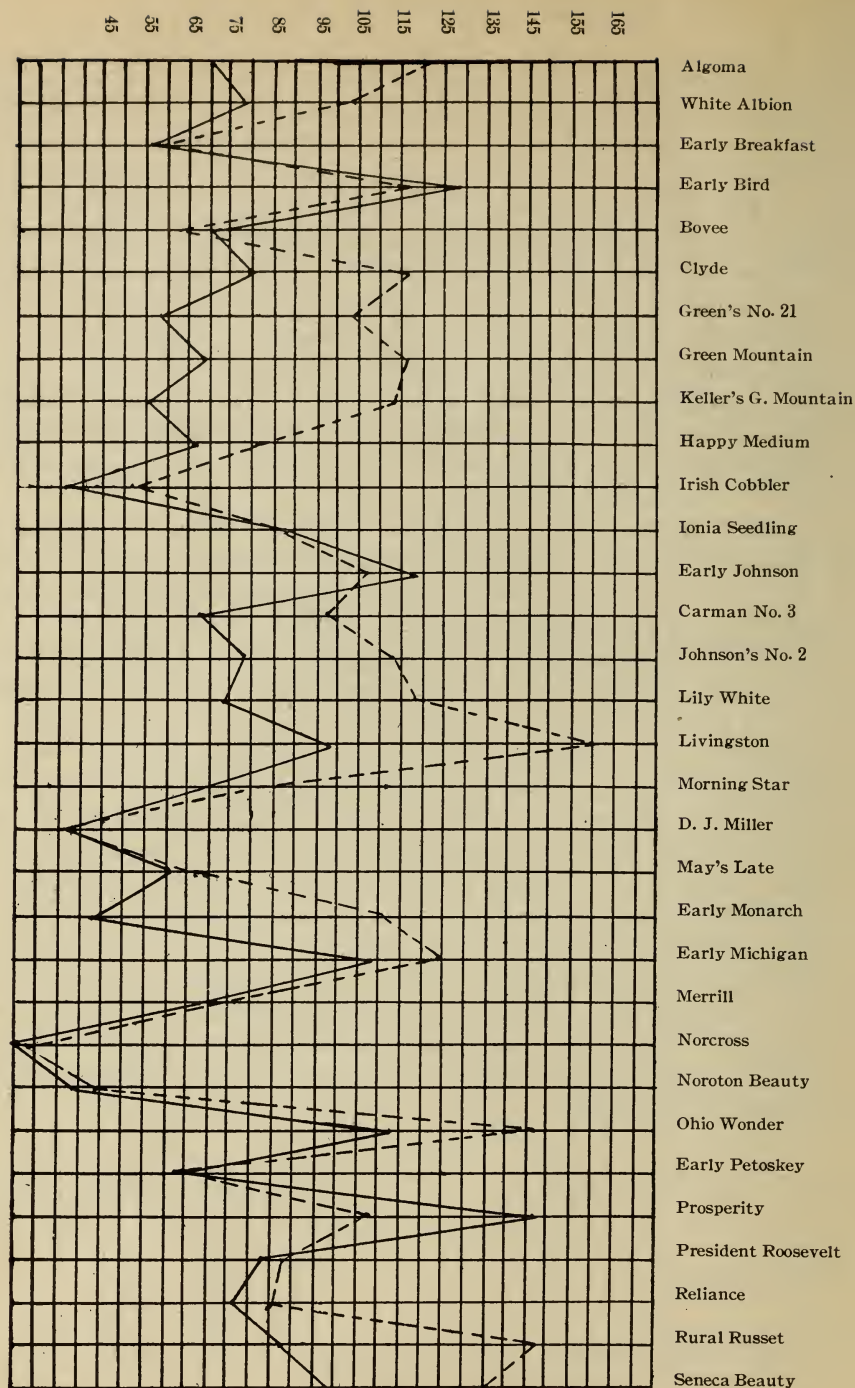


CHART I—Continued. Comparative yields of potatoes grown at Experiment Station on silt loam soil.

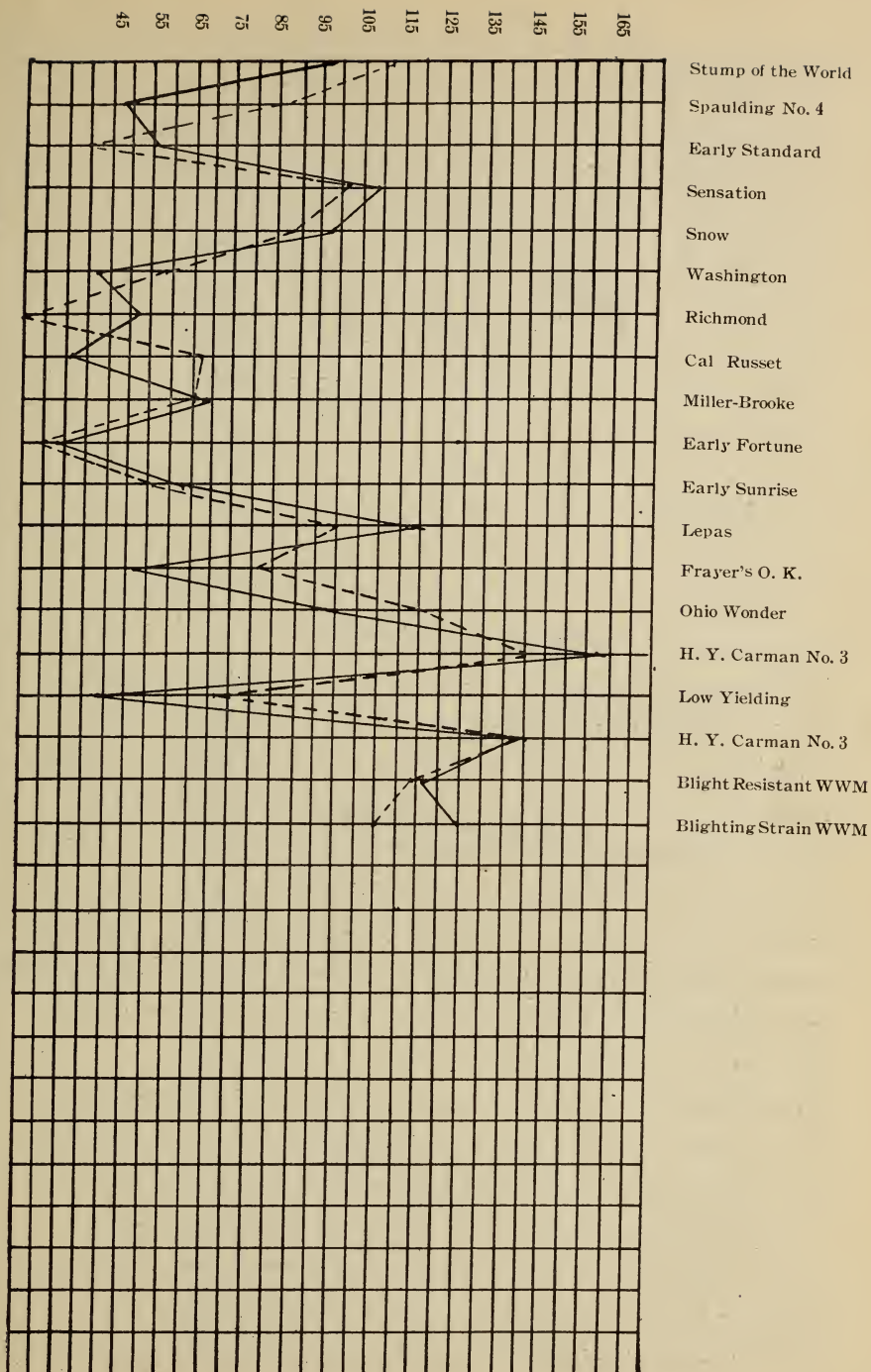
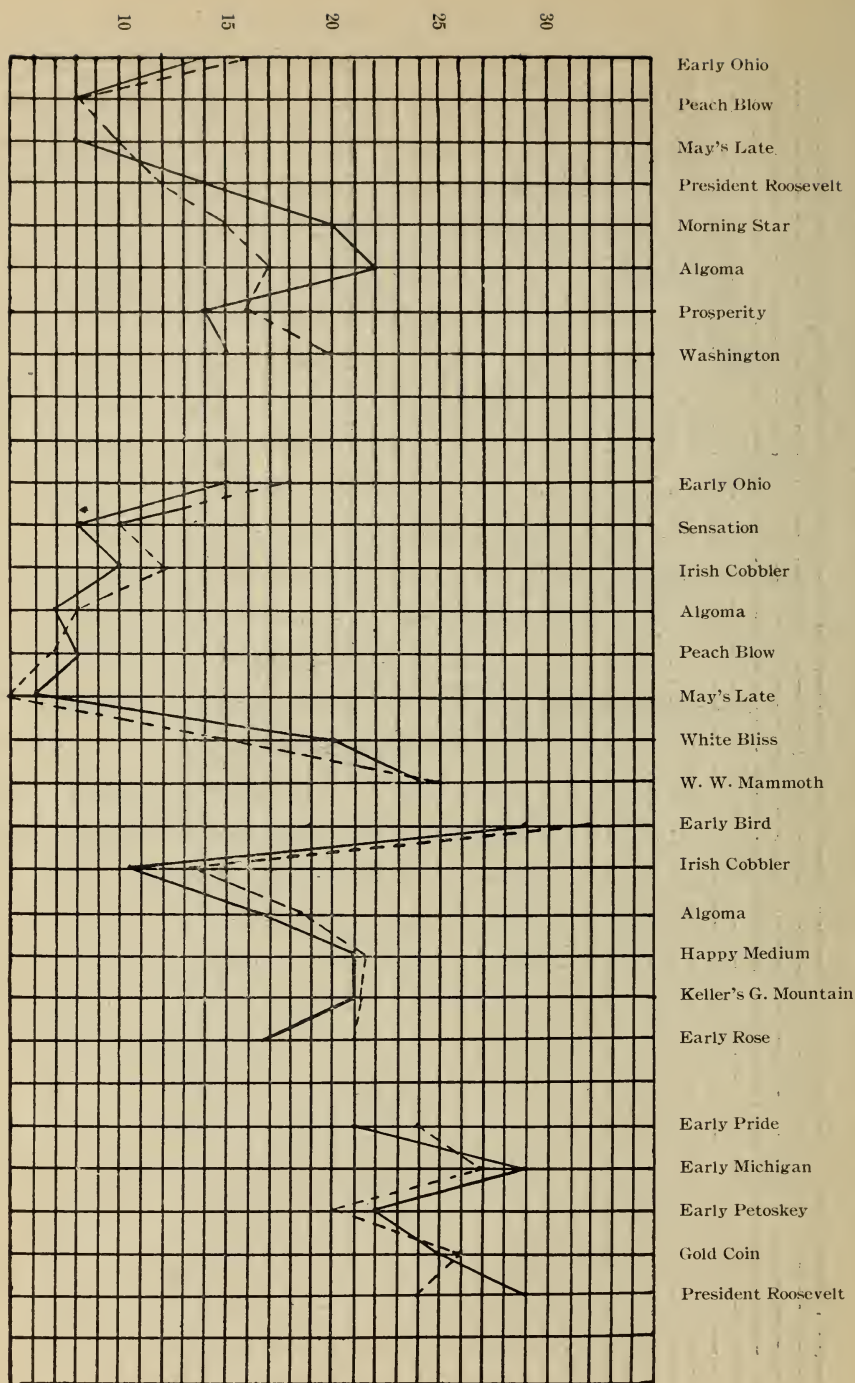
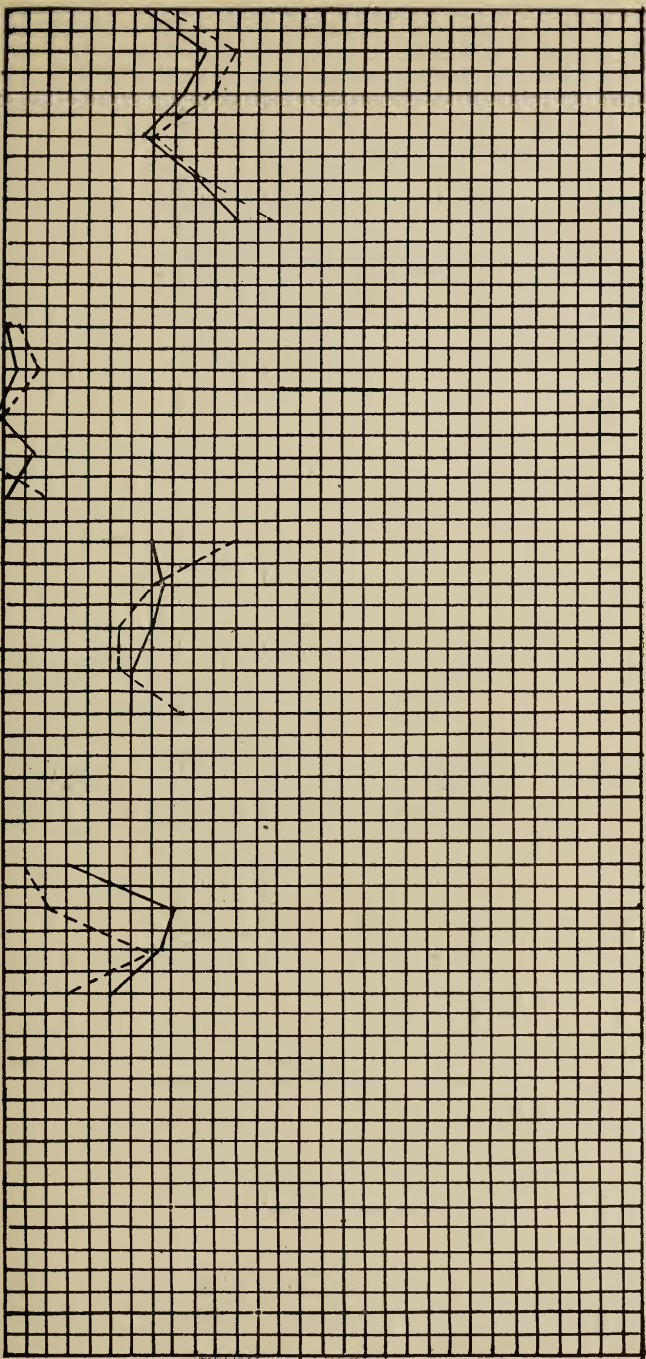


CHART II—Varieties of potatoes grown on clay soils.



10 15 20 25 30



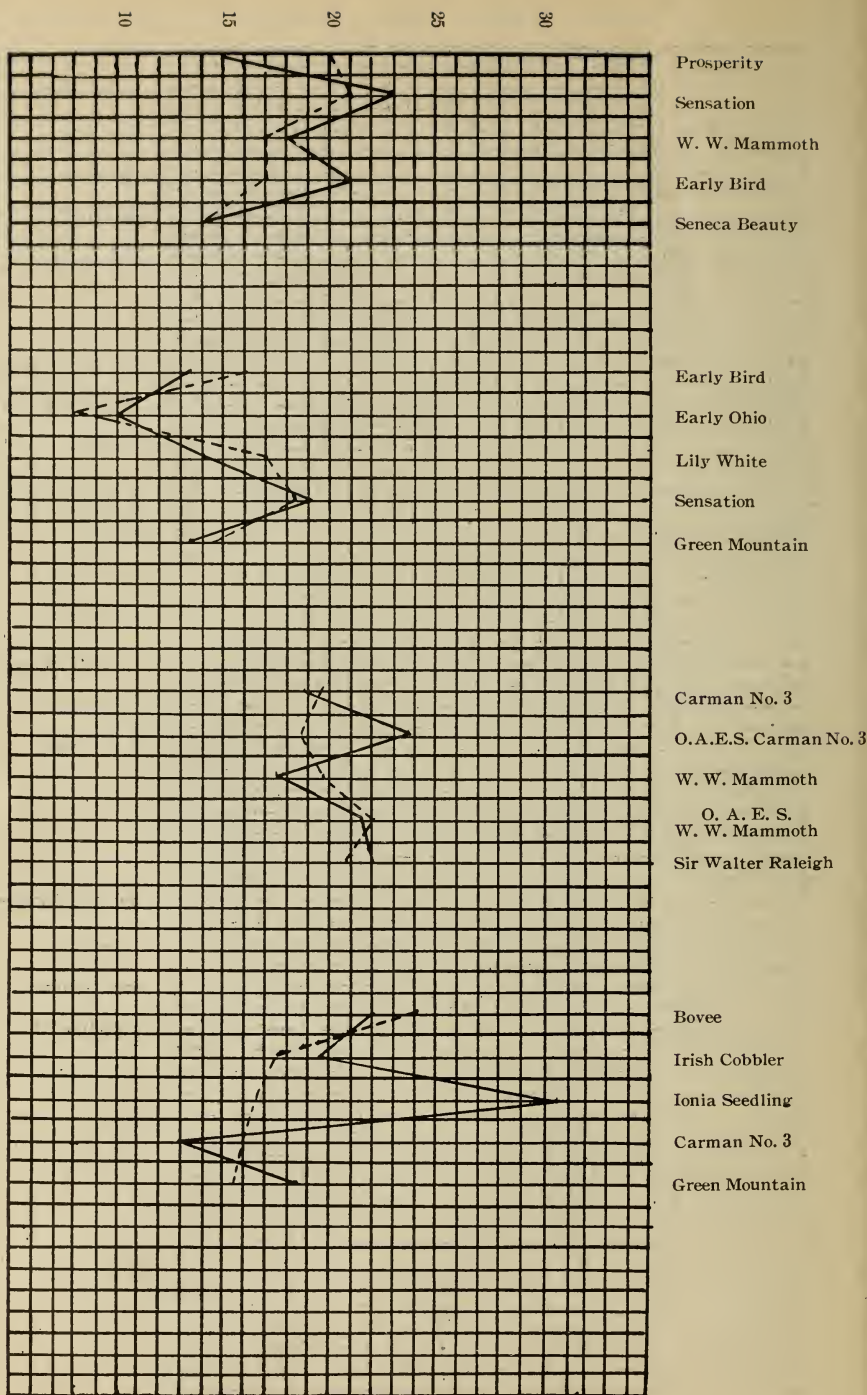
Bovee
 Irish Cobbler
 Gold Coin
 Prosperity
 Sensation
 Carman No. 3

 Ionia Seedling
 President Roosevelt
 Gold Coin
 W. W. Mammoth
 White Star
 Early Bird
 Irish Cobbler
 Early Michican
 Gold Coin
 Early Ohio

 President Roosevelt
 Sensation
 Ionia Seedling
 Spaulding No. 4

CHART III—Varieties of potatoes grown on muck soils.

CHART IV—Varieties of potatoes grown on sandy soil.



Ohio Agricultural Experiment Station.

CIRCULAR No. 91.

WOOSTER, OHIO, MARCH 20, 1909.

ALFALFA CULTURE.

BY C. G. WILLIAMS.

Alfalfa is being grown with more or less success in every county in this state; with greater success upon the rich and well drained limestone soils of the western half, than upon the shale clay and sandy loams of eastern Ohio, although under these much less favorable natural conditions success has been attained by many.

WHAT ALFALFA NEEDS.

A well drained soil. There are a number of conditions which are fatal to alfalfa. Among these, lack of drainage stands well to the front. Soils not having natural sub-surface drainage, i. e., a porous subsoil, should be tiled. While good surface drainage is helpful, trouble may be expected with a heavy, retentive subsoil, unless tile drainage is resorted to. Alfalfa will not thrive where the water level is permanently within three feet or less of the surface. It will stand flood water for a considerable time during the dormant season, unless the water freezes solid, but during the growing season two or more days' flooding is usually disastrous.

A sweet soil. No farm crop seems as sensitive to soil acidity as alfalfa. There is no use to seed alfalfa in Ohio where red clover fails to do well and sorrel is working in its place. Uplands usually become acid before bottom lands. As a general rule the first thing to do with all lands other than limestone, which have been in cultivation very many years, is to apply lime in some form. Not infrequently limestone soils which have been in cultivation for many years have had the lime pretty well leached out of the surface soil and will give better results if limed.

When in doubt as to whether lime is needed it is well to put out a small plot test to determine the needs of the soil.

Experiments conducted by this Station go to show that when soils are acid, no application of fertilizers or manures, nor any treatment of the soil in the way of inoculation is successful in growing alfalfa unless lime be first applied. Experiments to date indicate that fine ground limestone is effective in correcting soil acidity, but larger applications of the limestone are needed than of the caustic lime—practically double the amount. While soils vary as to the amount of lime needed, 2,000 lbs. of caustic lime, or 4,000 lbs. of ground limestone will care for most soils.

A rich soil. While alfalfa, like other legumes, may take care of its own nitrogen problem when once it gets well established with the proper nitrogen-gathering bacteria aiding it, yet a soil rich in all plant food constituents is an important factor in getting it established. For the purpose of enriching the soil for alfalfa there is nothing better than a liberal application of stable manure. This should not be applied to the surface soil just preceding the seeding of alfalfa for the weed seeds in the manure will make no end of trouble. If applied the same season the alfalfa is seeded it had better be plowed under. However, manure is best applied to a cultivated crop a year in advance of alfalfa seeding.

In the absence of manure it is well to make use of such leguminous catch crops as field peas, soybeans, cowpeas and the like, to fill the soil with humus-forming material. Then with an application of steamed bone and potash the fertility conditions should be well cared for.

Alfalfa is an unusually deep rooted plant and is thereby enabled to draw upon greater depths than most crops for phosphoric acid and potash, yet if good crops of alfalfa are to be grown year after year these constituents must be supplied at regular intervals.

A clean soil. In submitting a list of questions to alfalfa growers in Ohio some three years ago to ascertain as far as possible the reasons for success and failure with this crop it was found that by far more failures were ascribed to competition with weeds than to any other cause. To weeds and nurse crops (and they may not improperly be coupled together, for to an alfalfa plant they are indistinguishable) were ascribed 166 percent more failures than to all other causes mentioned.

Most soils are pretty well filled with weed seeds. It is a mistake to seed alfalfa in such soils until the weed problem has been solved. This may be accomplished in part, at least, by growing an inter-tilled crop as corn, potatoes, tobacco, etc., for one or two years previous to seeding alfalfa, and giving these crops very clean cultivation. It may be greatly helped by growing a cultivated crop like early potatoes the season of seeding, or a crop which will smother the weeds, as a thickly seeded crop of field peas. When the situation is critical enough to justify, the problem can be best solved perhaps by early plowing and giving clean fallow cultivation for 6 to 10 weeks previous to seeding. While this is expensive, it is pretty sure to result in a good, clean stand of alfalfa, and in the long run may prove economical.

An inoculated soil. Our various leguminous plants have the power, through the aid of microscopic organisms which live in nodules upon their roots, to make use of the uncombined nitrogen of the air. The presence of these organisms is very important in so far as the maintenance of the fertility of the soil is concerned and has much to do with the successful growing of some of the legumes. This is especially true regarding alfalfa. The early pages of the history of alfalfa growing in this country are filled with failure after failure until the ground *gradually became inoculated*. Experiments at this Station have shown that inoculation is very helpful in promoting the healthfulness and vigor of alfalfa and in increasing its yield. Plots growing side by side, with other conditions of growth identical save inoculation, have shown a gain of 1.26 tons of hay per acre in favor of soil inoculation for the three cuttings the year after seeding. It has been possible to distinguish between the inoculated and the uninoculated plots a half a mile away from them, simply by the difference in the color of the alfalfa—the inoculated plots being a very dark green, the uninoculated plots a pale, greenish yellow.

Alfalfa then, should not be seeded without first inoculating the soil with the proper nitrogen-gathering bacteria. The most effective way of accomplishing this is to take soil from an old alfalfa field where nodules are found upon the alfalfa roots, and apply it just before seeding, at the rate of 100 to 400 pounds per acre, depending upon the convenience and expense in securing the infected soil. This soil may be broadcasted by hand and harrowed in, or sifted and drilled in with a fertilizer drill. Care should be taken not to dry the infected soil in the sunlight, or let it lie in the sunlight after it is broadcasted before harrowing in, else most of the bacteria will be killed.

If it is more convenient to secure soil from a patch of sweet clover (*Melilotus alba*) it will prove as satisfactory, for the bacteria which work upon sweet clover work also upon alfalfa.

PREPARING FOR ALFALFA.

It should be remembered that alfalfa is no ordinary crop. That if successful it will last four or five years and perhaps longer. Accordingly mistakes made with this crop mean more than with our common annuals. As stated above, one should make his plans for alfalfa from one to three years in advance, filling the soil with organic matter and plant food and cleaning it of weeds. It is not possible to plow and prepare a good seed bed for alfalfa in a week's time, as is frequently done for other crops. Time is an important factor in

preparing a seed bed for alfalfa, and enough time should be taken to accomplish the desired result, viz., a firm, fine, moist and clean seed bed.

Preparatory crops. In the effort to avoid losing the use of the land the season alfalfa is seeded, a number of different crops have been grown in advance of seeding, among them early potatoes, oats, soybeans (cut for hay), field peas and wheat. Perhaps the safest crop to precede alfalfa is early potatoes. Potatoes may be gotten out of the way for late July or early August seeding and when they have been kept clean a good seed bed is speedily available. Next to potatoes, likely, stand field peas, as these come off early and leave a clean seed bed. Oats and soybeans are most too late for sure seedings of alfalfa. Wheat, while earlier, is more or less uncertain, much depending upon moisture conditions.

Nurse crop vs. seeding alone. This Station has tried a number of different nurse crops; among them wheat, oats, barley, corn and soybeans. Under our conditions none has proved successful. Wheat has seldom given success elsewhere. Under some conditions oats and barley have given success. Seeding with corn at last cultivation is uncertain. In soils well filled with humus, and with favorable conditions as regards moisture during August and September, good seedings may be secured.

When seeding early, i. e., April or May, it is usually more satisfactory to use a nurse crop than to seed alone. Barley is to be preferred, with oats second choice. Usually the latter had better be cut for hay.

When to seed. Mid summer seeding, without a nurse crop, upon land which has been thoroughly prepared, probably furnishes the most favorable conditions for securing a stand of alfalfa. This thorough preparation may consist of four to eight weeks of fallow cultivation, or of a preparatory crop, as early potatoes or peas, which is out of the way in good season.

Source and character of seed. Alfalfa varies widely in hardiness. With few exceptions we have found the southern grown seed to be tender and unable to withstand our Ohio climate. Northern and northwestern grown seed have quite uniformly given good satisfaction. No one should purchase alfalfa seed without knowing its source and first examining a sample for adulteration and seed impurities. The greatly increasing demand for alfalfa may have encouraged adulteration; at any rate it is occasionally met with. The

seed most commonly used to adulterate alfalfa is yellow trefoil (*Medicago lupulina*). Other adulterants sometimes used are sweet clover and bur clover. The weed pests to be especially guarded against are dodder and narrow-leaved plantain. Purchasers of seed who are not familiar with these and other possible impurities should submit a sample to the Botanist of the Experiment Station before purchasing. Such examination is made free of charge for residents of this state.

Manner of seeding. It makes but little difference how alfalfa seed is sown so that it is done evenly and is well covered. The Station has secured very satisfactory results distributing alfalfa seed through the grass seeding attachment of an ordinary grain drill, dropping the seed in front of the hoes, the latter covering it. This has given decidedly better results than drilling the seed, i. e., distributing it *through* the drill hoes the same as wheat. It may be seeded quite satisfactorily with many of the common grass seeders in use, and by broadcasting by hand. Where there is a possibility of uneven seeding it is well to divide the seed and cross seed. Except when covered with the drill hoes the seed should be harrowed in.

Rate of seeding. This Station put out a thick and thin seeding test of alfalfa June 27, 1907, at the rates of 5, 10, 15, 20 and 25 pounds of seed per acre. The seed was distributed through the grass-seeding attachment of an ordinary wheat drill after repeated and careful testing. It was dropped in front of and covered by the drill hoes.

The results of this test thus far appear in the following table:

THICK AND THIN SEEDING OF ALFALFA.

Pounds of seed used per acre.	No. plants per sq. ft. July 31, '07	No. plants per sq. ft. May 2, '08	Total pounds hay per acre, 1908 (3 cuttings)
5.....	13	11	7,862
10.....	33	27	8,648
15.....	45	34	8,678
20.....	56	44	8,557
25.....	70	49	7,876

The number of plants per square foot was determined by counting three tracts 1.5 ft. square in different parts of each plot and the average taken. The plots are one-fifth acre each.

It will be noted that the maximum yield was harvested from the plot receiving 15 lbs. of seed per acre, but that 10 lbs. of seed gave within 30 lbs. of as large a yield of hay per acre. The yield from 20 lbs. of seed is somewhat lower than from 10 and 15 lbs., and the yield from 25 lbs. decidedly lower, exceeding the yield from 5 lbs. by an insignificant amount.

It should be stated that 5 lbs. of seed per acre proved a little light in so far as holding the weeds in check is concerned. If a few large weeds had not been removed from this plot it would have presented a somewhat ragged appearance. This being done the quality of the alfalfa was as satisfactory as on any plot.

This ground was in ideal condition for alfalfa when seeded, having been plowed some eight weeks previous and harrowed at intervals of 10 to 20 days until seeded. Under such conditions 10 to 15 lbs. of seed per acre would seem to be enough. It is to be doubted whether more than 15 lbs. of alfalfa seed per acre is needed in this state when a good seed bed is prepared, and it is surely cheaper to prepare such a seed bed than to buy alfalfa seed to waste among clods, or in a loose, dried out soil.

In consulting the above table it will be observed that nature is taking a hand in weeding out unnecessary plants. Comparing the stand of plants per square foot May 2, 1908, with the stand July 31, 1907, there is a shrinkage of 15.3 percent where 5 lbs. of seed per acre were used and 30 percent where 25 lbs. were used.

Clipping young alfalfa. Spring seedlings of alfalfa will likely need one clipping. Mid summer seedlings may or may not need clipping. Alfalfa should hardly be clipped much later than the first of September, else, of an unfavorable season, it is not likely to go into the winter with sufficient growth for protection.

In 1907, this Station conducted a clipping experiment upon alfalfa which was seeded June 27th. A portion of the field was clipped September 9th. At that time the alfalfa stood 12 to 18 inches in height, about 15 percent was in bloom and the new growth, or tillers were well started. Another portion of the field was clipped October 16th. There was little change in the alfalfa during the period from September 9th to October 10th save that the blossoms had dried up. The weather conditions were about normal the fall of 1907, the rainfall for September being 3.13 inches; for October, 2.34 inches; and for November 1.33 inches.

In the spring it was very noticeable that the new growth started off earlier and stronger where the alfalfa was not clipped. The total yield for the three cuttings was 1,376 lbs. per acre greater from the

plot not clipped than from the plot clipped in September, and 522 lbs. greater than from the plot clipped in October. The injury from the October clipping appears to be less because of the weed growth that took the place of the injured alfalfa.

There seems little reason for clipping midsummer or later seedings of alfalfa the season of seeding, unless the alfalfa becomes diseased.

The old idea, that conflicts which weeds and alfalfa might be waging could be settled in favor of alfalfa by repeated clipping, is not well founded.

Making alfalfa hay. This is what one hopes to be doing, beginning the June following the year of seeding. When is alfalfa ready for harvest? There are several answers which may be given to this question, each of which should be taken into consideration. 1. When one-tenth to one-fourth of the bloom is out. 2. When the new growth is nicely started. 3. When it is at a stand-still as a result of one or many diseases to which alfalfa is subject. If one arbitrarily decides that alfalfa must not be cut until a certain percent of the bloom appears, he will sometimes wait in vain, waking up finally to find that his alfalfa is rapidly dropping its leaves and becoming less valuable every hour.

In order to make the best hay it is desirable to do as much of the curing as possible in the hay cock. Mowing in the middle part of the day when the weather promises fair, alfalfa should be ready to cock up in about 24 hours and should do the balance of its curing in the cock, save opening for a little while before hauling. In this way the leaves can be saved to best advantage, and they must be saved, for according to analyses made by this Station, 100 lbs. of leaves carry as much protein as 240 lbs. of stems.

Hay caps greatly simplify the matter of making good hay in bad weather. Good duck covers which will last a number of years can be purchased at from 25 to 50 cents each according to quality. Some farmers are using caps made from heavy unbleached muslin with good results.

ALFALFA DISCOURAGEMENTS.

Very many farmers have failed in their attempt to grow alfalfa. There is no disputing the fact that thousands of dollars have been lost upon unsuccessful alfalfa fields. Many of these losses might have been avoided. The reasons for some of these failures have already been enumerated in this circular. In brief they are: wet soil; acid soil; impoverished soil; weeds; lack of inoculation; poorly fitted seed bed; over nursing; ill-timed seeding; poor and weedy seed and excessive clipping.

Dodder. Dodder is a weed pest that has given much trouble. It is a "yellowish, thread-like, twining plant" which derives its sustenance from the host plant within its grasp, severing its connection with the soil and slowly carrying on its work of destruction. It gradually extends its domain and should be attended to when first discovered. If the infested spots are not numerous they may be dug out or burned over, using kerosene and any dry material as straw. If the area is very extensive the only recourse which is effective is plowing. The time for most efficient work, however, is when purchasing alfalfa seed. If only dodder-free seed be used there will be no infested fields.

Leaf spot. Leaf spot (*Pseudopeziza medicaginis*) is a fungous disease which is doing a great deal of damage in this state and seems to be present everywhere. It may be readily recognized by the small brown or black spots on the alfalfa leaves. The lower leaves are attacked first but it gradually extends over the whole plant. The badly diseased leaves usually turn yellow and drop, and fields that are allowed to stand until over ripe become quite bare of leaves in the lower half of the plant. There is no effective remedy for leaf spot. This disease may be held in check by cutting, and fields that are affected badly enough to stop growing should be harvested at once. Nothing is gained by letting such fields stand and frequently much is lost. The disease spreads rapidly and the dropping of the leaves reduces the food value of the crop. The new growth generally comes in much freer from leaf spot than the preceding crop. The second and third cuttings are more likely to be injured than the first crop.

Leaf spot is frequently called rust and blight.

SHOULD EVERY FARMER GROW ALFALFA?

Likely not. Some farmers will not find a convenient place for this long-time perennial in their farm rotations. They will be content with red clover, which, upon many soils, is a close second to alfalfa. At this Station the past season (1908) red clover gave a yield of 4.34 tons per acre at two cuttings, while under very similar conditions alfalfa yielded 4.66 tons at three cuttings. There is not very much difference between 4.34 and 4.66 tons, while there is some difference between two hayings and three hayings—but not enough to make up for the difference in the quality of the product in favor of alfalfa.

Upon some Ohio farms it is probable that red clover is, and for some time may be, a surer crop than alfalfa. The latter should be tried under conditions which have been made favorable, but in a small way, until its utility is demonstrated. A failure under more or less unfavorable conditions does not necessarily mean continued failure.

5.7
0436
cop. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Ohio Agricultural Experiment Station.

CIRCULAR No. 92.

WOOSTER, OHIO, MARCH 20, 1909.

PLANS AND SUMMARY TABLES

OF THE EXPERIMENTS AT THE CENTRAL FARM, WOOSTER,

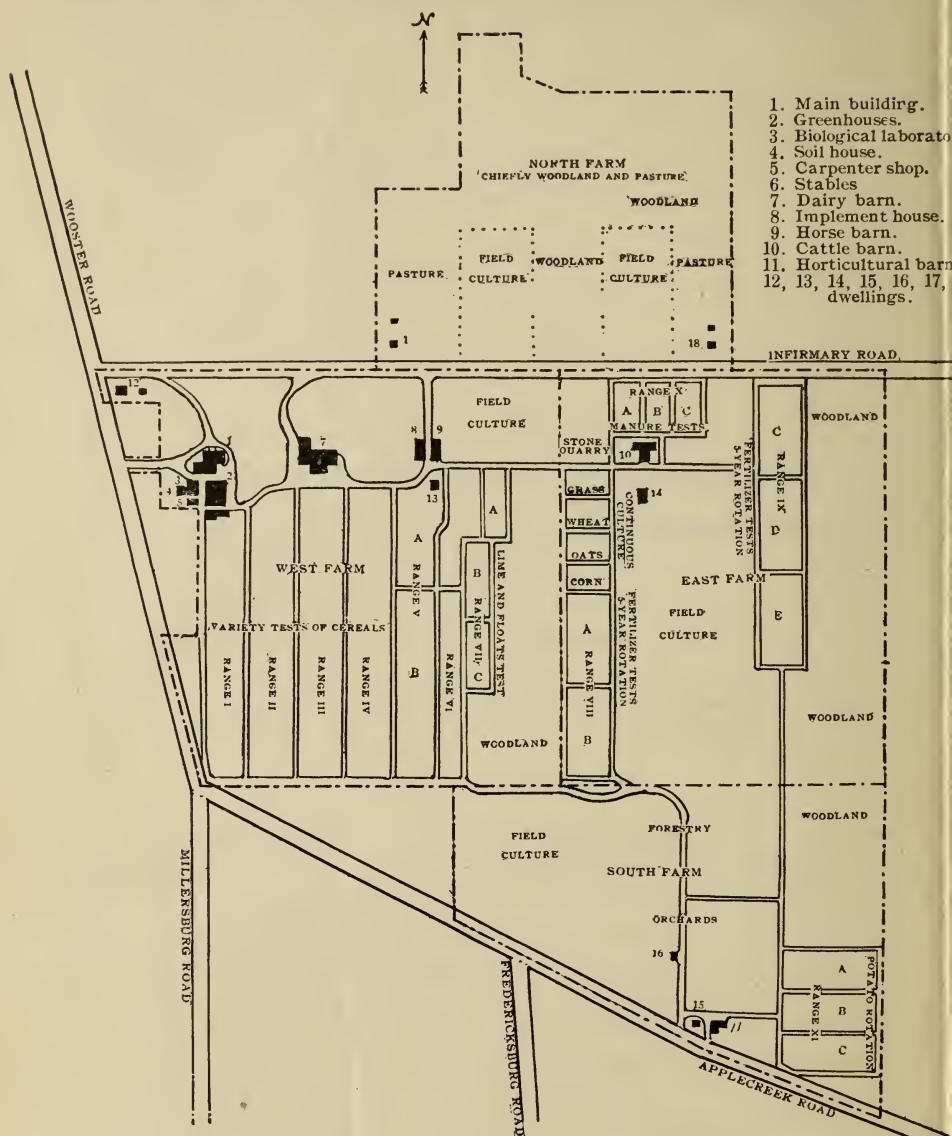
ON THE

MAINTENANCE OF SOIL FERTILITY

ARRANGED FOR REFERENCE IN THE FIELD.

ANNOUNCEMENT.

The experiments reported in the following pages were begun in 1893, immediately after the removal of the Experiment Station to Wayne county. The general plan of this work and the results obtained up to that time are published in Bulletin 110, issued in December, 1899, (now out of print) and again in Bulletins 182, 183 and 184, reporting to the end of 1906. It now seems desirable to follow these general publications with a brief annual statement, giving as briefly as possible the new data obtained from each successive crop, and referring the reader to Bulletins 182 and 183 for more complete information respecting the nature of the soils under experiment and the general plan of the work.



The central farm, near Wooster.

FERTILIZERS AND MANURE ON CROPS GROWN CONTINUOUSLY ON THE SAME LAND.

Wheat, oats and corn, one acre (10 plots) each, have been grown in this experiment since 1894. The fertilizers are applied to Plots 2 and 8 in arbitrary quantities, while on Plots 3 and 9 the three fertilizing elements, nitrogen, phosphorus and potassium, are given in approximately the same ratio to each other in which they are found in the plant.

The applications to Plots 2 and 8 have in every case produced larger yields than those to Plots 3 and 9, but this may in part be accounted for by the combined nitrogen which is carried to the soil in rain, thus enabling the crops grown on 2 and 8 to utilize larger quantities of the phosphorus and potassium given in the fertilizer than merely that required to balance the fertilizer nitrogen.

The manure applications on plots 5 and 6 were intended to carry nitrogen in quantities equivalent to the applications on Plots 2 and 3 on the one hand and 8 and 9 on the other, estimating the manure to carry 10 pounds of nitrogen per ton, but actual analyses of manure, made during recent years, indicate that this estimate was too high for open yard manure, such as is used in these tests. The average application of phosphorus and potassium in the manure closely approximates the average given to the four fertilized plots.

In this test the corn and wheat show a rapid falling off in yield on the unfertilized land during recent years. The oats also show a reduction in yield, but not so great as that of the other crops.

It is much more difficult to control the weed growth in the wheat and oats grown continuously than where the same crops are grown in rotation, and it has been necessary to divide these tracts and fallow the two ends in alternate seasons in order to destroy the weeds.

Diagram I shows the arrangement of plots and plan of fertilizing in this experiment, and the general outcome is shown in Table I, which gives the yields by periods.

DIAGRAM I: PLAN OF FERTILIZING IN CONTINUOUS CULTURE,

[Fertilizing materials in pounds per acre.]

Wheat

- | | |
|----|---|
| 1 | None. |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160. |
| 3 | Acid phos., 60; muriate potash, 30; nitrate soda, 160. |
| 4 | None. |
| 5 | Yard manure, 2½ tons. |
| 6 | Yard manure, 5 tons. |
| 7 | None. |
| 8 | Acid phos., 160; muriate potash, 100; nitrate of soda, 320. |
| 9 | Acid phos., 120; muriate potash, 60; nitrate of soda, 320. |
| 10 | None. |

Oats

- | | |
|----|--|
| 1 | None. |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160. |
| 3 | Acid phos., 55; muriate potash, 50; nitrate soda, 160. |
| 4 | None. |
| 5 | Yard manure, 2½ tons. |
| 6 | Yard manure, 5 tons. |
| 7 | None. |
| 8 | Acid phos., 160; muriate potash, 100; nitrate soda, 320. |
| 9 | Acid phos., 110; muriate potash, 100; nitrate soda, 320. |
| 10 | None. |

Corn

- | | |
|----|--|
| 1 | None. |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160. |
| 3 | Acid phos., 45; muriate potash, 30; nitrate soda, 160. |
| 4 | None. |
| 5 | Yard manure, 2½ tons. |
| 6 | Yard manure, 5 tons. |
| 7 | None. |
| 8 | Acid phos. 160; muriate potash, 100; nitrate soda, 320. |
| 9 | Acid phos., 90; muriate potash, 60; nitrate soda, 320. |
| 10 | None. |

(South)

TABLE 1: YIELD AND INCREASE PER ACRE OF CROPS GROWN IN CONTINUOUS CULTURE.

Plot No.	Fertilizing materials. Pounds per acre.	1908				15 years, 1894-1908.				Plot No.
		Yield		Increase		Yield		Increase		
		Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	
Corn										
1	None	16.89	1 330	23.47	830	22.71	1 410	22.21	1 410	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160	37.54	2 060	7.14	800	43.44	2 966	15.57	2 966	2
3	" " " 60; " " 30; " " 160	18.39	1 930			35.32	1 909		1 909	3
4	None	8.43	1 030			18.26	1 235		1 235	4
5	Yard manure, 2½ tons	20.11	1 620	12.28	573	29.81	1 739	22.06	1 739	5
6	" " 5	30.07	1 950	22.83	887	39.29	2 089	22.05	2 089	6
7	None	6.64	1 080	32.80	1 187	16.71	1 199	31.50	1 199	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320	38.21	2 190	29.20	1 093	47.18	2 317	30.25	2 317	8
9	" " 120; " " 60; " " 320	33.39	2 020			44.88	2 187		2 187	9
10	None	2.96	850			13.58	1 033		1 033	10
Average unfertilized yield		8.73	1 072			18.27	1 238			
Oats										
1	None	17.11	702	23.88	1 467	21.34	775	20.58	1 037	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160	41.24	2 150	21.60	1 231	42.60	1 845	15.97	1 770	2
3	" " " 55; " " 50; " " 160	39.21	1 895			38.67	1 608			3
4	None	17.86	1 645	5.80	313	23.37	1 871	7.84	299	4
5	Yard manure, 2½ tons	24.06	1 030	12.82	480	31.46	1 205	14.71	730	5
6	" " 5	31.48	1 268			38.56	1 671			6
7	None	19.06	860	27.96	1 562	24.10	977	24.01	1 392	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320	47.18	2 440	25.08	1 350	48.50	2 368	21.79	1 247	8
9	" " 110; " " 100; " " 320	44.45	2 247			46.63	2 220			9
10	None	19.53	915			25.23	972			10
Average unfertilized yield		18.39	780			23.51	899			
Wheat										
1	None	8.53	1 270	20.10	2 309	8.12	1 100	11.42	1 380	1
2	Acid phos., 160; mur. potash, 100; nit. soda, 120; dried blood, 50	28.95	3 540	13.29	1 466	19.70	2 442	7.09	1 817	2
3	" " " 45; " " 30; " " 120; " " 50	22.46	2 657			15.51	1 841			3
4	None	9.49	1 152	20.08	1 856	8.57	986	4.72	654	4
5	Yard manure, 2½ tons	22.33	2 431	23.73	2 345	13.26	1 648	8.73	1 139	5
6	" " 5	30.04	3 365	21.37	2 048	17.24	1 012	14.05	1 338	6
7	None	10.20	1 537			8.48	2 814	12.22	1 455	7
8	Acid phos., 160; mur. potash, 100; nit. soda, 200; dried blood, 50	32.97	3 727			22.28	2 306			8
9	" " 90; " " 60; " " 200; " " 50	29.65	3 274			20.19	2 306			9
10	None	7.32	1 071			7.72	905			10
Average unfertilized yield		8.88	1 257			8.22	1 000			

THE 5-YEAR ROTATION.

In this experiment corn, oats, wheat, clover and timothy are grown in succession on five tracts of land, A, B, C, D and E, containing 30 one-tenth acre plots each. Sections A and B of this test lie in Range VIII, south of the areas devoted to continuous cropping, while Sections C, D and E occupy Range IX, near the east side of the farm.

The land was underdrained in 1893, and corn was grown that season on Section C. The planting was delayed by the draining and the season proved unfavorable, so that the results of that season's work have not been included in the average. In 1894 wheat was harvested on Section A, oats on Section C and corn on Section D. The clover and timothy followed the wheat on Section A in 1895 and 1896, and the rotation has since been regularly followed.

Beginning with 1900 lime has been applied to the west half of each plot in this rotation, fertilized and unfertilized alike, while the land was being prepared for corn, the lime being applied at the rate of one ton per acre of ground quicklime in 1900, 1901, 1902 and 1903, applied in the spring after plowing, and for 1904 applied the previous fall. In 1905 the liming was changed to the east half, a ton of quicklime being used that spring, but in 1906 and 1907 ground limestone was used, at the rate of two tons per acre. In 1908 the liming was discontinued. The table gives the average yield for the entire plot in each case, averaging the limed and unlimed halves.

In 1895 and 1906, and again in 1899, 1900 and 1901 the wheat in this test was injured by Hessian fly, the yield on the unfertilized land falling to a small fraction over one bushel per acre in 1896 and 1900.

Diagram II shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the five sections being arranged and treated exactly alike. Tables II to X inclusive give the yields per acre.

DIAGRAM II: PLAN OF FERTILIZING IN 5-YEAR ROTATION.

[illegible]

TABLE II: YIELD AND INCREASE PER ACRE OF CORN GROWN IN 5-YEAR ROTATION, 1908 AND 15 YEARS, 1894 TO 1908.

Plot No.	Fertilizing materials Pounds per acre.	1908				15 years, 1894-1908				Plot No.
		Yield		Increase		Yield		Increase		
		Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	
1	None	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	1
2	Acid phosphate, 80	23.35	1,410	...	...	31.72	1,664	7.83	231	2
3	Acid phosphate, 80	33.89	1,740	10.09	313	39.42	1,891	...	...	3
4	Muriate potash, 80	26.68	1,710	2.42	267	36.21	1,924	4.74	266	4
5	None	24.71	1,460	...	...	31.34	1,655	...	...	5
6	Nitrate soda, 160	33.71	1,690	7.59	187	36.33	1,831	4.69	176	6
7	Acid phosphate, 80; nitrate soda, 160	43.36	1,870	15.84	323	45.96	2,018	14.03	362	7
8	None	28.93	1,590	...	...	32.22	1,657	...	...	8
9	Acid phosphate, 80; muriate potash, 80	42.87	2,020	14.32	413	45.10	2,182	13.60	551	9
10	Muriate potash, 80; nitrate soda, 160	35.07	1,730	6.93	107	36.69	1,905	5.92	300	10
11	None	27.75	1,640	...	...	30.05	1,579	...	...	11
12	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160	44.64	2,040	17.92	450	48.44	2,273	18.07	698	12
13	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160	43.32	2,000	17.50	460	48.71	2,288	18.02	698	13
14	Fertilized on wheat only	24.35	1,490	...	...	31.02	1,655	...	...	14
15	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160*	38.21	1,700	13.89	157	45.87	2,208	15.66	555	15
16	None	23.25	1,740	5.10	143	28.65	1,850	7.76	236	16
17	Acid phosphate, 160; muriate potash, 80; nitrate soda, 80†	44.96	1,650	20.16	123	47.17	1,648	17.72	576	17
18	Barnyard manure, 8 tons each on corn and wheat	54.32	2,110	27.94	447	50.65	2,405	19.94	698	18
19	None	27.93	1,670	...	...	32.32	1,736	...	...	19
20	Barnyard manure, 4 tons each on corn and wheat	42.25	1,970	14.58	327	44.10	2,174	12.89	463	20
21	Same elements as 17, but nitrogen in oilmeal	43.03	1,900	15.63	283	28.99	2,254	16.73	567	21
22	None	27.14	1,590	...	...	28.91	1,662	...	...	22
23	Same elements as 17, but nitrogen in dried blood	46.39	2,000	18.30	377	46.91	2,254	16.92	563	23
24	Same elements as 17, but nitrogen in sulphate ammonia	50.75	1,850	21.70	193	47.68	2,289	16.70	568	24
25	None	30.00	1,690	...	...	31.98	1,749	...	...	25
26	Same elements as 11, but phosphorus in bonemeal	43.54	2,190	10.51	403	46.91	2,319	14.18	542	26
27	Same elements as 11, but phosphorus in dissolved bone black	48.25	2,040	11.39	157	48.22	2,307	14.73	501	27
28	None	39.39	1,980	...	...	34.25	1,834	...	...	28
29	Same elements as 11† but phosphorus in basic slag	49.25	2,370	9.86	390	49.33	2,410	15.09	576	29
30	Same elements as 17, but nitrogen in tankage†	52.11	2,020	12.72	40	47.70	2,235	13.46	400	30
	Average unfertilized yield	27.71	1,617	...	...	31.25	1,683	...	...	

* Fertilized on corn and wheat only. † Since first rotation: previously same quantities of elements as 11. ‡ Since second rotation: previously this plot received less fertilizer.

TABLE III: YIELD AND INCREASE PER ACRE OF CORN BY 5-YEAR PERIODS. GRAIN ONLY.

Plot	Fertilizing materials.	1894-1898			1899-1903			1904-1908			Plot
		Yield	Increase	Bus.	Yield	Increase	Bus.	Yield	Increase	Bus.	
No.	Pounds per acre.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	No.	
2	Acid phosphate, 80.....	36.02	3.96	41.90	9.74	40.33	9.78	40.33	9.78	2	
3	Muriate potash, 80.....	34.93	2.69	36.14	4.74	37.55	6.79	37.55	6.79	3	
5	Nitrate soda, 160.....	35.38	2.33	36.24	5.75	37.37	6.01	37.37	6.01	5	
6	Acid phosphate, 80, nitrate soda, 160.....	43.32	9.65	47.61	17.26	46.95	15.17	46.95	15.17	6	
8	Acid phosphate, 80; muriate potash, 80.....	40.11	7.21	44.49	14.17	50.69	19.40	50.69	19.40	8	
9	Muriate potash, 80; nitrate soda, 160.....	33.00	1.48	36.62	6.19	40.47	10.10	40.47	10.10	9	
11	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160.....	41.28	10.72	49.90	19.45	54.13	24.04	54.13	24.04	11	
12	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160.....	41.07	10.09	52.18	21.82	52.88	22.14	52.88	22.14	12	
14	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160.....	40.96	10.27	47.81	18.33	48.85	18.37	48.85	18.37	14	
15	Fertilized on wheat only.....	32.26	5.92	35.52	6.83	39.13	9.42	39.13	9.42	15	
17	Acid phosphate, 160; muriate potash, 80; nitrate soda, 80.....	36.78	6.59	43.54	20.48	53.91	23.87	53.91	23.87	17	
18	Barley and manure, 8 tons each on corn and wheat.....	40.73	10.04	49.52	19.32	59.75	28.48	59.75	28.48	18	
20	Barley and manure, 4 tons each on corn and wheat.....	38.91	7.10	43.08	12.83	50.31	18.74	50.31	18.74	20	
21	Same elements as 17, but nitrogen in oilmeal.....	37.66	7.16	48.79	19.63	54.03	23.39	54.03	23.39	21	
23	Same elements as 17, but nitrogen in dried blood.....	37.68	7.71	49.51	19.90	53.53	23.16	53.53	23.16	23	
24	Same elements as 17, but nitrogen in sulphate ammonia.....	40.51	9.75	49.44	18.27	53.11	22.08	53.11	22.08	24	
26	Same elements as 11, but phosphorus in bonemeal.....	39.14	6.22	50.31	17.30	51.28	19.01	51.28	19.01	26	
27	Same elements as 11, but phosphorus in dissolved boneblack.....	40.61	6.29	53.25	19.96	50.81	17.95	50.81	17.95	27	
29	Same elements as 11, but phosphorus in basic slag.....	43.89	8.19	53.36	19.77	50.75	17.30	50.75	17.30	29	
30	Same elements as 17, but nitrogen in tankage.....	41.73	6.02	46.51	12.93	51.87	21.42	51.87	21.42	30	
Average unfertilized yield.....		31.89	.....	30.82	.....	31.04	.....	31.04	.....		

Table III shows that there has been a general increase in the yield per acre on the fertilized and manured plots during the three periods of the experiment, while the unfertilized yield has remained almost stationary. This increase has been much greater on the plots receiving the complete fertilizer, containing the three elements, nitrogen, phosphorus and potassium, than on those receiving only one or two elements. The use of lime has improved the yield during the last period, but the lime has been applied to fertilized and unfertilized land alike.

TABLE IV: YIELD AND INCREASE PER ACRE OF OATS GROWN IN 5-YEAR ROTATION: 1908, AND 15 YEARS, 1894-1908.

Plot		Fertilizing materials	1908				15 years, 1894-1908				Plot
			Yield		Increase		Yield		Increase		
No.	Pounds per acre.	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	No.	
1	None	45.54	2,102			32.59	1,313			1	
2	Acid phosphate, 80	52.73	2,482	9.61	332	40.24	1,655	7.97	281	2	
3	Muriate potash, 80	50.86	2,627	10.16	430	35.59	1,386	3.64	99	3	
4	None	38.28	2,235			31.63	1,273			4	
5	Nitrate soda, 160	41.09	2,335	2.53	173	35.70	1,415	4.19	155	5	
6	Acid phosphate, 80; nitrate soda, 160	53.75	2,750	14.90	670	46.50	1,847	13.11	601	6	
7	None	39.14	1,997			31.27	1,233			7	
8	Acid phosphate, 80; muriate potash, 180	55.15	3,085	13.36	946	42.69	1,677	11.51	512	8	
9	Muriate potash, 80; nitrate soda, 160	46.48	2,462	2.03	182	36.23	1,488	4.75	257	9	
10	None	47.10	2,422			31.59	1,230			10	
11	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160	53.75	3,350	9.51	993	49.86	2,155	18.33	901	11	
12	" " " " " "	48.36	3,132	6.98	540	48.88	2,230	17.42	952	12	
13	None	38.51	2,227			31.40	1,301			13	
14	Fertilized on corn and wheat only	48.28	2,665	8.70	509	38.89	1,651	8.13	386	14	
15	Fertilized on wheat only	42.65	2,375	2.00	289	32.34	1,301	2.47	127	15	
16	None	41.72	2,015			29.50	1,167			16	
17	Acid phosphate, 160; muriate potash, 80; nitrate soda, 80*	56.32	3,627	14.50	1,499	47.39	2,126	17.49	930	17	
18	Manured on corn and wheat	47.42	2,962	3.49	720	38.87	1,743	10.71	641	18	
19	None	42.03	2,355			30.72	1,252			19	
20	Manured on corn and wheat	48.59	2,745	6.77	448	36.95	1,560	6.51	328	20	
21	Same elements as 17, but nitrogen in oilmeal	55.62	3,560	14.00	1,318	46.72	2,066	13.44	779	21	
22	None	41.41	2,185			29.86	1,194			22	
23	Same elements as 17, but nitrogen in dried blood	53.51	3,347	12.10	1,095	46.85	2,008	16.50	776	23	
24	Same elements as 17, but nitrogen in sulphate ammonia	54.92	3,632	13.57	1,312	48.27	2,220	17.43	948	24	
25	None	41.32	2,387			31.34	1,312			25	
26	Same elements as 11, but phosphorus in bonemeal	50.78	3,115	10.58	799	46.71	1,970	14.98	673	26	
27	Same element as 11, but phosphorus in dissolved boneblack	47.11	3,262	8.02	1,016	49.35	2,163	17.22	881	27	
28	None	37.97	2,175			32.52	1,267			28	
29	Same elements as 11, but phosphorus in basic slag	44.92	3,202	6.95	1,027	47.42	2,012	14.90	744	29	
30	Same elements as 17, but nitrogen in tankage†	45.39	3,047	7.42	872	43.69	1,836	11.17	569	30	
Average unfertilized yield		41.30	2,241			31.24	1,256				

* Since first rotation: previously same quantities of elements as 11. † Since second rotation: previously this plot received less fertilizer.

TABLE V: YIELD AND INCREASE PER ACRE OF OATS BY 5-YEAR PERIODS. GRAIN ONLY.

Plot	Fertilizing materials.	1894-1899			1899-1903			1894-1908			Plot
		Yield		Increase	Yield		Increase	Yield		Increase	
		Bus.	Bus.		Bus.	Bus.		Bus.	Bus.		
No.	Pounds per acre.										No.
2	Acid phosphate, 80	37.63	5.34		37.37	8.66		45.72	9.91		2
3	Muriate potash, 80	34.71	2.32		33.70	4.62		38.34	3.97		3
5	Nitrate soda, 160	35.40	3.11		34.89	5.95		36.80	3.50		5
6	Acid phosphate, 80; nitrate soda, 160	40.36	8.26		48.75	20.32		50.41	16.75		6
8	Acid phosphate, 80; muriate potash, 150	38.26	6.87		40.92	12.72		48.89	14.34		8
9	Muriate potash, 80; nitrate soda, 160	33.36	2.46		35.75	7.26		39.60	4.53		9
11	Acid phosphate, 80; muriate potash, 80; nitrate soda, 160	43.61	12.92		52.48	23.74		53.49	18.35		11
12	Acid phosphate, 80; muriate potash, 80; nitrate soda, 240	45.11	14.11		52.37	23.65		49.16	14.49		12
14	Fertilized on corn and wheat only	36.79	6.19		37.18	9.23		42.69	8.95		14
15	Fertilized on wheat only	30.31	.....		30.25	3.51		36.46	3.19		15
17	Acid phosphate, 160; muriate potash, 80; nitrate soda, 80	38.03	8.57		49.19	22.51		54.97	21.68		17
18	Manured on corn and wheat	36.91	5.20		40.36	12.90		46.71	12.93		18
20	Manured on corn and wheat	32.39	7.58		36.45	9.05		42.00	7.90		20
21	Same elements as 17, but nitrogen in oilmeal	37.43	7.78		50.64	24.51		52.87	18.93		21
23	Same elements as 17, but nitrogen in dried blood	39.81	9.94		48.67	21.75		52.06	17.80		23
24	Same elements as 17, but nitrogen in sulphate ammonia	43.01	12.76		49.29	21.79		52.52	17.73		24
26	Same elements as 11, but phosphorus in bonemeal	43.04	12.11		47.11	18.00		49.98	14.82		26
27	Same elements as 11, but phosphorus in dissolved boneblack	43.54	12.29		51.59	21.48		52.91	17.89		27
29	Same elements as 11, but phosphorus in basic slag	42.49	10.93		49.19	18.08		50.58	15.70		29
30	Same elements as 17, but nitrogen in tankage	35.47	3.91		45.78	14.65		49.83	14.96		30
	Average unfertilized yield	30.91	.....		28.30	....		34.50	.....		
	Average yield and increase from complete fertilizers	39.89	10.14		46.98	18.55		49.79	15.37		

The oats crop shows a marked increase in the unfertilized yield during the third period of the test, the gain on the unfertilized plots being much larger than that on those receiving fertilizers and manure, the result of which is an apparent falling off in the effectiveness of the fertilizer. The total yields, however, are larger during the third period than during the second on every plot except No. 12, receiving the heavy dressing of nitrate of soda. The increasing tendency to lodge on this plot probably accounts for its smaller yield. The manured plots show a smaller increase of oats than those receiving the complete fertilizers, but the manure is all applied to the corn and wheat. The outcome on these plots, as on Plots 14 and 15, indicates that it is better to apply manure and fertilizers to every crop, rather than only to certain crops in the rotation.

TABLE VI: YIELD AND INCREASE PER ACRE OF WHEAT GROWN IN 5-YEAR ROTATION: 1907, AND 15 YEARS, 1894 TO 1908.

		1908				15 years, 1894-1908				
Plot	Fertilizing materials.	Yield		Increase		Yield		Increase		Plot
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	
No.	Pounds per acre	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	No.
1	None.....	21.16	2,350	.....	.....	10.42	1,128	.....	.....	1
2	Acid phosphate, 160.....	30.16	2,770	9.22	493	18.38	1,851	7.83	727	2
3	Muriate potash, 100.....	22.45	2,302	1.73	99	11.97	1,275	1.29	156	3
4	None.....	20.50	2,130	.....	.....	10.81	1,118	.....	.....	4
5	Dried blood, 50; nitrate soda, 120.....	22.12	2,492	1.90	495	12.77	1,421	1.96	303	5
6	Acid phosphate, 160; dried blood, 50; nitrate soda, 120.....	37.12	3,442	17.18	1,579	24.06	2,456	13.24	1,335	6
7	None.....	19.66	1,730	.....	.....	10.81	1,123	.....	.....	7
8	Acid phosphate, 160; muriate potash, 100.....	29.54	2,797	9.27	947	19.65	1,846	8.86	741	8
9	Muriate potash, 100; dried blood, 50; nitrate soda, 120.....	24.25	2,725	3.37	755	13.51	1,440	2.75	353	9
10	None.....	21.49	2,090	.....	.....	10.73	1,069	.....	.....	10
11	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 120.....	41.45	4,002	20.03	1,968	27.03	2,846	16.30	1,766	11
12	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 200.....	35.58	4,015	14.22	2,037	27.97	2,929	17.20	1,838	12
13	None.....	21.29	1,922	.....	.....	10.79	1,101	.....	.....	13
14	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 120 ¹	39.70	3,747	20.40	1,959	25.25	2,633	14.89	1,585	14
15	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 120 ²	34.75	3,085	17.43	1,431	24.01	2,453	14.08	1,459	15
16	None.....	15.33	1,520	.....	.....	9.51	941	.....	.....	16
17	Acid phos., 160; mur. potash, 100; dried blood, 25; nit. soda, 60 ³	34.16	3,250	18.11	1,647	22.11	2,211	12.35	1,234	17
18	Barnyard manure, 8 tons.....	33.25	2,955	16.47	1,268	20.55	2,200	10.54	1,187	18
19	None.....	17.50	1,770	.....	.....	10.26	1,049	.....	.....	19
20	Barnyard manure, 4 tons.....	27.46	2,582	9.78	806	16.87	1,809	6.72	781	20
21	Same elements as 17, but nitrogen in oilmeal.....	31.16	2,880	13.30	1,069	23.39	2,407	13.36	1,400	21
22	None.....	18.04	1,787	.....	.....	9.92	986	.....	.....	22
23	Same elements as 17, but nitroren in dried blood.....	31.71	2,837	13.46	986	22.18	2,187	11.93	1,153	23
24	Same elements as 17, but nitrogen in sulphate ammonia.....	32.79	3,052	14.35	1,136	22.77	2,264	12.20	1,182	24
25	None.....	18.66	1,980	.....	.....	10.90	1,129	.....	.....	25
26	Same elements as 11, but phosphorus in bone meal.....	31.95	2,782	13.32	937	23.49	2,372	12.69	1,282	26
27	Same elements as 11, but phosphorus in dissolved boneblack.....	35.83	3,330	17.22	1,680	26.36	2,639	15.65	1,589	27
28	None.....	18.58	1,575	.....	.....	10.63	1,011	.....	.....	28
29	Same elements as 11, but phosphorus in basic slag.....	33.37	3,157	14.79	1,582	24.61	2,518	13.98	1,506	29
30	Same elements as 17, but nitrogen in tankaget.....	30.50	2,900	11.92	1,325	21.97	2,119	11.34	1,108	30
A average unfertilized yield.....		19.50	1,932	.....	.....	10.49	1,068	.....	.....	

¹ Fertilized on corn and wheat only. ² Fertilized on wheat only. ³ Since first rotation; previously same quantities of elements as 11. ⁴ Since second rotation; previously this plot received less fertilizer.

TABLE VII.—YIELD AND INCREASE PER ACRE OF WHEAT BY 5-YEAR PERIODS, GRAIN ONLY.

Plot.	Fertilizing materials. Pounds per acre	1894-1898		1899-1903		1904-1908		Plot
		Yield	Increase	Yield	Increase	Yield	Increase	
2	Acid phosphate, 160	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	2
3	Muriate potash, 100	12.35	3.14	18.67	9.81	24.13	10.54	3
5	Dried blood, 50; nitrate soda, 120	11.26	1.64	9.54	.86	15.11	1.37	5
6	Acid phosphate, 160; dried blood, 50; nitrate soda, 120	11.57	1.54	10.58	2.10	16.16	2.23	6
8	Acid phosphate, 160; muriate potash, 100	16.84	6.81	24.47	16.00	30.87	16.92	8
9	Muriate potash, 100; dried blood, 50; nitrate soda, 120	15.20	5.22	19.78	11.31	23.96	10.06	9
11	Acid phosphate, 160; muriate potash, 100; dried blood, 50; nitrate soda, 120	12.09	2.15	11.12	2.61	17.31	3.48	11
12	Acid phosphate, 160; muriate potash, 100; dried blood, 50; nitrate soda, 200	20.53	10.73	27.46	18.82	33.10	19.32	12
14	Acid phosphate, 160; muriate potash, 100; dried blood, 50; nitrate soda, 120	20.95	11.23	29.37	20.61	33.58	19.77	14
15	Acid phosphate, 160; muriate potash, 100; dried blood, 50; nitrate soda, 120	18.11	8.92	25.55	17.10	32.10	18.65	15
17	Acid phosphate, 160; muriate potash, 100; dried blood, 50; nitrate soda, 60	16.77	8.04	24.80	16.80	30.46	17.39	17
18	Barnyard manure, 8 tons	13.84	5.55	23.20	15.39	28.98	16.11	18
20	Barnyard manure, 4 tons	12.65	4.35	19.02	10.97	29.97	16.90	20
21	Same elements as 17, but nitrogen in oilmeal	11.48	3.25	14.67	6.41	24.47	10.52	21
23	Same elements as 17, but nitrogen in dried blood	18.35	10.20	23.88	15.66	27.95	14.24	23
24	Same elements as 17, but nitrogen in sulphate ammonia	16.78	8.14	23.28	14.71	26.47	12.95	24
26	Same elements as 11, but phosphorus in bone meal	17.85	8.64	22.97	14.02	27.48	13.93	26
27	Same elements as 11, but phosphorus in dissolved boneblack	18.17	8.33	25.07	15.07	28.12	14.66	27
29	Same elements as 11, but phosphorus in basic slag	18.86	8.94	28.72	19.81	31.53	18.20	29
30	Same elements as 17, but nitrogen in tankage	18.71	8.73	26.58	17.88	28.54	15.34	30
		14.66	4.68	23.90	15.20	27.35	14.15	
Average unfertilized yield		9.28	....	8.55	...	13.66	....	
Average yield and increase from complete fertilizers		17.88	7.51	16.76	25.32	29.66	16.23	

The wheat crop, like the oats, shows a large increase in the unfertilized yield during the third period as compared with either of those preceding. This is due in part to better seasonal conditions, in part to the use of lime during the last period, but chiefly to the deliverance from insect depredations, there having been severe attacks of Hessian fly in 1895 and 1896 and again in 1899 to 1901. While, therefore, the total yield is much larger on every plot during the third period than before, the average increase from the fertilizer is not any greater.

TABLE VIII: YIELD AND INCREASE PER ACRE OF CLOVER AND TIMOTHY GROWN IN 5-YEAR ROTATION: 1908 AND DURING THE ENTIRE PERIOD OF THE EXPERIMENT.

Plot	Total quantities of fertilizing materials applied to previous crops of the rotation. None on clover or timothy.	1908				Entire period				Plot
		Clover		Timothy		Clover, 14 years		Timothy, 13 years		
		Yield	Increase	Yield	Increase	Yield	Increase	Yield	Increase	
No.	Pounds per acre	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	No.
1	None.....	3,013		2,062	.....	1,818		2,853		1
2	Acid phosphate, 320.....	5,404	2,560	3,004	957	2,410	552	3,079	266	2
3	Muriate potash, 260.....	5,289	2,614	2,106	74	2,165	266	2,915	141	3
4	None.....	2,506		2,017		1,939		2,734		4
5	Nitrate soda, 440; dried blood, 50.....	2,880	430	2,889	854	2,251	352	3,138	456	5
6	Acid phosphate, 320; nitrate soda, 440; dried blood, 50.....	5,493	3,100	3,492	1,439	2,997	1,139	3,438	809	6
7	None.....	2,337		2,070		1,818		2,578		7
8	Acid phosphate, 320; muriate potash, 260.....	6,035	3,858	3,324	1,229	2,738	916	3,046	490	8
9	Muriate potash, 260; nitrate soda, 440; dried blood, 50.....	2,426	408	2,747	629	2,187	362	2,931	396	9
10	None.....	1,858		2,142		1,828		2,515		10
11	Acid phos., 320; mur. potash, 260; nit. soda, 440; dried blood, 50.....	4,968	3,018	4,195	1,940	3,123	1,317	3,582	1,053	11
12	Acid phos., 320; mur. potash, 260; nit. soda, 440; dried blood, 50.....	5,440	3,389	4,187	1,820	3,229	1,445	3,474	931	12
13	None.....	2,133		2,480		1,763		2,556		13
14	Acid phos., 240; mur. potash, 18; nit. soda, 280; dried blood, 50.....	4,018	1,986	3,102	705	2,762	1,041	3,210	691	14
15	Acid phos., 160; mur. potash, 10; nit. soda, 120; dried blood, 50.....	3,422	1,490	2,800	485	2,347	670	2,940	427	15
16	None.....	1,831		2,231		1,636		2,446		16
17	Acid phos., 480; mur. potash, 260; nit. soda, 220; dried blood, 25.....	5,484	3,543	3,982	1,703	2,906	1,223	3,186	697	17
18	Yard manure, 16 tons.....	6,400	4,350	5,528	3,202	3,659	1,927	4,014	1,482	18
19	None.....	2,160		2,373		1,777		2,574		19
20	Yard manure, 8 tons.....	3,964	2,035	3,346	2,213	2,809	1,116	3,446	961	20
21	Same elements as 17, but nitrogen in oilmeal.....	4,871	3,173	3,315	1,422	2,636	1,026	3,050	655	21
22	None.....	1,467		1,653		1,526		2,306		22
23	Same elements as 17, but nitrogen in dried blood.....	4,978	3,455	2,986	1,152	2,601	990	3,022	614	23
24	Same elements as 17, but nitrogen in sulphate ammonia.....	5,813	4,234	3,395	1,380	2,718	1,023	3,222	948	24
25	None.....	1,635		2,195		1,779		2,611		25
26	Same elements as 11, but phosphorus in bonemeal.....	6,631	4,777	3,848	1,748	3,293	1,468	3,637	946	26
27	Same elements as 11, but phosphorus in dissolved boneblack.....	5,582	3,508	3,342	1,336	2,893	1,023	3,449	681	27
28	None.....	2,293		1,911		1,916		2,847		28
29	Same elements as 11, but phosphorus in basic slag.....	5,671	3,378	3,600	1,689	3,064	1,148	3,797	950	29
30	Same elements as 17, but nitrogen in tankage.....	6,400	4,107	3,813	1,502	3,046	1,130	3,743	896	30
Average unfertilized yield.....		2,123		2,113		1,780		2,602		

TABLE IX: YIELD AND INCREASE PER ACRE OF CLOVER AND TIMOTHY HAY BY PERIODS.

[illegible]

** Average unfertilized yield.

* Average unfertilized yield.

Table IX shows that there was a general falling off in the yield of hay during the second period on the fertilized and manured land, as well as on that left untreated. In the case of the clover crop the only exceptions to this rule of diminishing yields are found on Plot 5, receiving nitrate of soda only, and Plots 26 and 29, to which the phosphorus has been given in bone meal and basic slag, respectively. The reduction in yield has been smaller on all the plots receiving nitrate of soda than on those receiving other carriers of nitrogen. (Plots 21, 23 and 24) On these plots both total yield and rate of increase are less during the second period than during the first. Plot 30 cannot be compared during this period, as a change in the fertilizer of this plot was made at the beginning of the second period. During the third period, under the influence of lime, there has been a marked gain, both in the total yield and the rate of increase.

TABLE X: TOTAL FERTILIZING MATERIALS AND THEIR COST FOR EACH ROTATION, AND TOTAL AND NET VALUE OF INCREASE PRODUCED FOR 5-YEAR PERIODS AND FOR 15 YEARS.

Plot No.	Fertilizing materials in pounds per acre for each rotation.	Cost of fertilizers	Total value of increase per acre				Net gain or loss (-) from fertilizers			Plot No.
			First 5 years	Second 5 years	Third 5 years	15-year average	First 5-years	Second 5-years	Third 5-years	15-year average
2	Acid phosphate, 320.	\$ 2.60	\$ 8.50	\$17.37	\$24.32	\$16.43	\$ 5.90	\$14.77	\$21.72	\$13.83
3	Muriate potash, 260.	6.50	5.19	4.67	9.17	6.31	-1.31	-1.83	2.67	-19
5	Nitrate soda, 440; dried blood, 50.	14.40	4.70	4.70	9.03	8.67	-9.70	-4.00	-5.37	-5.73
6	Acid phosphate, 320; nitrate soda, 440; dried blood, 50.	17.00	19.09	35.27	39.75	31.00	2.09	18.27	22.45	14.00
8	Acid phosphate, 320; muriate potash, 260.	9.10	14.40	24.37	33.51	23.62	5.30	15.27	24.41	14.52
9	Muriate potash, 260; nitrate soda, 440; dried blood, 50.	20.90	5.85	11.35	13.23	10.09	-15.05	-9.55	-6.67	-10.81
11	Acid phos., 320; mur. potash, 260; nit. soda, 440; dried blood, 50.	23.50	26.39	42.43	49.46	38.94	2.80	18.83	26.46	15.44
12	Acid phos., 320; mur. potash, 260; nit. soda, 440; dried blood, 50.	30.70	26.46	49.43	48.24	39.50	-1.54	14.83	17.54	8.80
14	Acid phos., 240; mur. potash, 180; nit. soda, 280; dried blood, 50.	16.05	21.37	32.31	37.53	30.37	5.32	15.86	21.38	14.32
15	Acid phos., 100; mur. potash, 100; nit. soda, 120; dried blood, 50.	8.60	13.89	22.86	27.13	21.44	5.29	14.26	18.53	12.94
17	Acid phos., 480; mur. potash, 200; nit. soda, 220; dried blood, 25.	17.60	15.74	36.61	46.28	32.93	-1.86	19.01	28.68	15.33
18	Yard manure, 16 tons.	?	19.82	34.24	55.94	36.18	?	?	?	?
20	Yard manure, 8 tons.	?	13.02	21.28	35.36	22.63	?	?	?	?
21	Same elements as 17, but nitrogen in oilmeal.	17.60	20.43	36.25	42.24	31.77	2.83	18.65	24.64	14.17
23	Same elements as 17, but nitrogen in dried blood.	17.60	19.09	34.37	39.28	30.45	1.49	16.77	21.68	12.85
24	Same elements as 17, but nitrogen in sulphate ammonia.	17.60	20.70	32.77	38.71	30.48	3.10	14.77	21.11	12.88
26	Same elements as 11, but phosphorus in bone meal.	23.50	20.86	36.17	42.55	32.75	-2.61	12.67	19.05	9.25
27	Same elements as 11, but phosphorus in dissolved bone black.	23.50	19.86	39.88	42.08	33.62	-3.64	16.38	18.58	10.12
29	Same elements as 11, but phosphorus in basic slag.	23.50	21.91	39.32	39.04	33.20	-1.50	15.82	15.54	9.70
30	Same elements as 17, but nitrogen in tankage.	*17.60	13.74	30.31	41.62	28.21	....	12.90	24.02	10.61

The nearest practicable approach to a common denominator for the various kinds of produce grown in this rotation is their market value, and in Table XI the results of the test are arranged on this basis for three 5-year periods and for the entire 15 years, corn being rated at 40 cents per bushel, oats at 30 cents, wheat at 80 cents, hay at \$8.00 per ton, stover at \$5.00 and straw at \$2.00; valuations much below present prices for the grains, but not far from the average values during the period of the test.

The fertilizing materials are valued at a fraction over \$16.00 per ton for acid phosphate, 2½ cents per pound for muriate of potash and 3 cents per pound for nitrate of soda; and it is assumed that the cost per pound of the fertilizing elements will be practically the same in the other carriers used on Plots 21 to 30 inclusive.

The table shows that the effectiveness of the fertilizers and manure has increased with each successive period, the greatest relative increase being shown by the fertilizer applications failed to produce sufficient increase to cover their nitrate; during the second period three, and during the third period two. Every complete fertilizer has been used with a profit since the first period, but when either nitrate of soda or muriate of potash has been used unaccompanied by some carrier of phosphorus there has been a loss in each period and in the average of the 15 years.

Nevertheless, both nitrogen and potassium are essential to the highest net profit, as shown by comparing Plot 2, receiving phosphorus only, with Plot 8, receiving potassium in addition and Plot 11, receiving these with nitrogen.

The results of the comparison of different carriers of nitrogen and phosphorus will be discussed in Circular No. 93.

* For last 2 periods.

THE POTATOES-WHEAT-CLOVER ROTATION.

This experiment is located on the South farm, south-east of the orchards, and contains three sections of 34 plots each. The south section (A) and about half of the middle section (B) had been in cultivation for an unknown period before the test began. The north part of Section B and all of the north section (C) were cleared from the forest for the purposes of this test. The old land was tile drained in 1893 and the work was begun by planting Section A to potatoes in 1894. Wheat and clover followed in 1895 and 1896 and the rotation has been maintained regularly since.

The potato crops in this test have in some seasons been somewhat injured by blight, and in 1904 a dashing rain, coming just after the potatoes had been planted, washed much of the seed out of the ground. These difficulties have caused an irregular stand, and for this reason the results have been "corrected" on the basis of the average stand obtained on the unfertilized plots. Both actual and "corrected" yields are given in the table.

In 1895 and 1896 the wheat in this test was severely injured by Hessian fly, but it escaped the attack of 1899 to 1901.

In 1900 the clover failed: attempts were made to grow crimson clover and soy beans in its stead, but there was failure in securing a stand of these crops also, so that it has been necessary to omit that season from the calculations. In 1905 continuous rains prevented harvesting the clover until very late, and caused the fertilized plots to lodge, so that these plots weighed less than those not fertilized, though earlier in the season they had shown a distinctly stronger growth. As there was no way by which the yields could be corrected and as it seemed desirable to include the crop in the general average because of its effect on the average unfertilized yield it has been so included, although the doing so slightly reduces the apparent average effect from the fertilizers.

[Fertilizing materials in pounds per acre.]

Plot No.	On Potatoes			On Wheat			
	Acid Phosphate	Muriate of potash	Nitrate of soda	Acid phos- phate	Muriate of potash	Dried blood	Nitrate of soda

1	....	...	....	....	....	....	....
2	160	....	....	160	....	....	....
3	....	100	....	....	100	....	....
4	....	....	....	....	....	....	....
5	...	....	80	....	....	50	120
6	160	....	80	160	....	50	120
7	....	....	....	....	....	....	....
8	160	100	....	160	100	....	....

9	....	100	80	....	100	50	120
10	.. .	...	....	....	...	...	...
11	160	100	80	160	100	50	120
12	160	100	160	160	100	50	200
13	....	...	...	....	...	...	...
14	320	200	160	160	100	50	120
15	480	300	320	....	....	...	....
16	....	...	....	....	....	....	....

17	....	....	....	Manure, 4 tons			
18	....	....	....	Manure, 8 tons			
19	....	....	....	....	....	....	....
20	160	100	80	160	100	25	60
21	Same elements as 20, but nitrogen in oilmeal						
22	....	....	....	....	....	....	....
23	Same elements as 20, but nitrogen in dried blood						
24	Same elements as 20, but nitrogen in sulphate ammonia						

25	....	....	....	....	....	....
26	Same elements as 11, but phosphorus in bone meal					
27	Same elements as 11, but phosphorus in dissolved bone black					
28	....	....	....	....	....	....
29	Same elements as 11, but phosphorus in basic slag					
30	Manure, 8 tons					
31	....	....	....	....	....	....
32	Manure, 16 tons					
33	Same elements as 20, but nitrogen in tankage					
34	....	....	....	....	....	....

DIAGRAM IV; ARRANGEMENT OF PLOTS IN POTATOES-WHEAT-CLOVER ROTATION.

PLOTS ONE-TENTH ACRE.

North

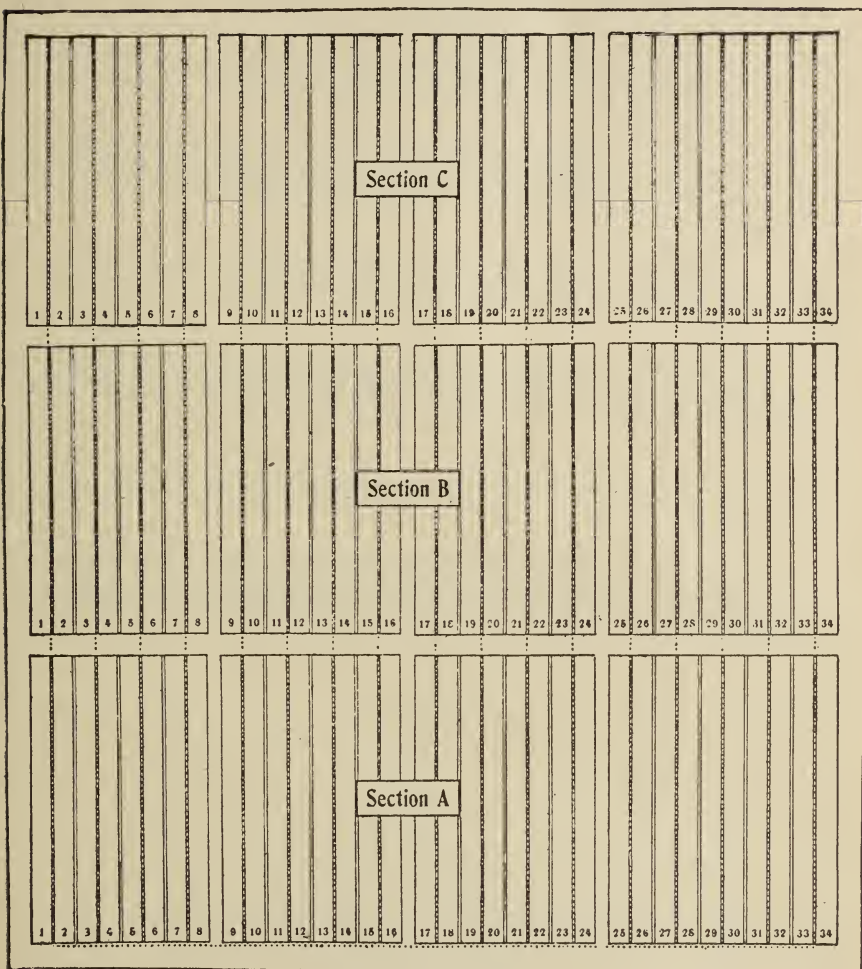


TABLE XI: YIELD AND INCREASE OF *POTATOES* GROWN IN ROTATION WITH WHEAT AND CLOVER, 1908 AND 15 YEARS, 1894-1909.

Plot	No.	Fertilizing materials	1908				15 years, 1894-1909			
			Actual		Corrected		Actual		Corrected	
			Yield	Increase	Yield	Increase	Yield	Increase	Yield	Increase
		Pounds per acre	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.
1	1	None	118.82	...	124.93	...	166.05	...	170.76	...
2	2	Acid phosphate, 160	133.33	1.28	130.46	-3.62	182.62	14.99	185.32	14.58
3	3	Muriate potash, 100	154.75	9.48	151.97	9.47	178.79	9.52	181.83	13.71
4	4	None	158.50	23.00	151.29	...	170.87	...	174.81	...
5	5	Nitrate soda, 80	170.92	9.48	167.04	26.95	175.49	9.08	178.28	11.66
6	6	Acid phosphate, 160; nitrate soda, 80	135.75	-1.58	128.09	-81	182.74	20.79	186.07	24.14
7	7	None	126.75	...	117.70	...	157.48	...	157.25	...
8	8	Acid phosphate, 160; muriate potash, 100	194.58	67.55	183.18	64.35	189.09	30.66	192.82	34.46
9	9	Muriate potash, 100; nitrate soda, 80	154.50	27.20	142.63	22.70	171.79	12.36	174.78	15.32
10	10	None	127.58	...	121.08	...	160.80	...	160.56	...
11	11	Acid phosphate, 160; muriate potash, 100; nitrate soda, 80	166.17	35.92	153.95	30.97	184.08	24.18	184.35	24.87
12	12	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160	176.67	43.76	163.74	41.07	191.27	31.71	190.83	32.90
13	13	None	135.58	...	126.47	...	159.09	...	157.28	...
14	14	Acid phosphate, 320; muriate potash, 200; nitrate soda, 160	184.83	55.92	172.80	49.09	187.82	35.91	196.24	41.82
15	15	Acid phosphate, 480; muriate potash, 300; nitrate soda, 320	184.83	62.58	206.32	81.49	191.89	35.91	194.94	43.51
16	16	None	115.58	...	118.18	...	148.53	...	148.50	...
17	17	Yard manure, 4 tons on wheat only	115.92	3.73	118.37	5.81	158.25	10.68	157.75	11.83
18	18	Yard manure, 8 tons on wheat only	135.25	26.44	139.51	32.56	162.71	17.21	162.21	19.09
19	19	None	105.42	...	101.33	...	145.64	...	143.00	...
20	20	Acid phosphate, 160; muriate potash, 100; nitrate soda, 80	165.71	59.00	191.15	83.00	188.73	42.26	189.25	44.34
21	21	Same elements as 20, but nitrogen in oilmeal	167.50	59.50	189.74	74.78	180.46	33.14	181.74	34.93
22	22	None	109.29	...	121.78	...	148.15	...	148.73	...
23	23	Same elements as 20; but nitrogen in dried blood	150.25	46.58	175.17	51.60	173.71	27.76	181.93	34.06
24	24	Same elements as 20, but nitrogen in sulphate ammonia	175.17	59.13	182.29	57.78	182.99	35.31	181.00	34.58
25	25	None	139.42	...	123.87	...	147.35	...	146.16	...
26	26	Same elements as 11, but phosphorus in bone meal	166.17	49.22	183.41	58.35	176.03	28.31	176.03	28.18
27	27	Same elements as 11, but phosphorus in dissolved bone black	166.92	52.45	189.87	65.61	182.98	34.18	185.76	36.19
28	28	None	112.00	...	123.45	...	149.42	...	151.25	...
29	29	Same elements as 11, but phosphorus in basic slag	167.83	42.79	179.68	46.15	180.87	29.32	184.84	30.54
30	30	Yard manure, 8 tons on potatoes only	182.46	43.50	208.70	65.09	193.23	39.31	200.00	42.69
31	31	None	152.00	...	153.69	...	156.16	...	160.34	...
32	32	Yard manure, 16 tons on wheat only	191.42	43.17	195.47	47.86	180.09	37.12	195.00	44.43
33	33	Same elements (since 1899) as 20, but nitrogen in tankage	177.42	32.92	173.60	32.06	173.13	33.13	185.42	34.19
34	34	None	140.75	...	135.46	...	138.97	...	144.96	...
		Average unfertilized yield	127.64	...	126.75	...	154.55	...	154.74	...

TABLE XII. YIELD AND INCREASE OF POTATOES-WHEAT-CLOVER ROTATION BY 6-YEAR PERIODS.

Plot	Fertilizing materials	Actual yield and increase				Corrected yield and increase				Plot
		1894-1899		1900-1905		1894-1899		1900-1905		
		Yield	Increase	Yield	Increase	Yield	Increase	Yield	Increase	
No.	Pounds per acre	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	Bus.	No.
1	None	157.57		180.49		157.88		190.92		1
2	Acid phosphate, 160	178.25	18.77	202.33	18.02	178.68	18.10	209.57	18.43	2
3	Muriate potash 100	170.30	8.90	191.26	3.13	172.79	9.51	204.33	12.98	3
4	None	163.31		191.95		165.98		191.57		4
5	Nitrate soda, 80	167.64	6.17	191.46	6.93	171.15	8.30	195.62	10.59	5
6	Acid phosphate, 160; nitrate soda, 80	185.17	25.45	193.53	16.42	188.25	28.53	200.06	21.58	6
7	None	157.91		169.08		156.69		171.94		7
8	Acid phosphate, 160; muriate potash, 100	183.30	24.55	190.43	18.41	180.62	23.23	204.33	29.76	8
9	Muriate potash, 100; nitrate soda, 80	175.83	16.28	167.81	-6.54	173.73	15.54	179.35	2.15	9
10	None	160.42		176.68		158.99		179.84		10
11	Acid phosphate, 160, muriate potash, 100; nitrate soda, 80	177.17	18.32	193.65	15.85	175.89	18.44	197.64	18.30	11
12	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160	186.09	28.81	198.19	19.27	182.42	27.63	202.57	23.73	12
13	None	155.70		180.03		154.38		178.55		13
14	Acid phosphate, 320; muriate potash, 200; nitrate soda, 160	183.34	27.37	197.42	24.61	186.01	30.61	208.65	35.99	14
15	Acid phosphate, 480; muriate potash, 300; nitrate soda, 320	193.61	37.38	181.12	15.52	191.98	37.79	196.94	30.48	15
16	None	156.49		158.39		154.09		160.27		16
17	Yard manure, 4 tons on wheat only	*180.22	*12.03	167.97	11.33	155.39	*8.22	170.31	12.99	17
18	Yard manure, 8 tons on wheat only	*182.34	*13.10	173.42	18.53	154.69	*13.61	175.00	20.62	18
19	None	155.43		163.13		151.20		151.43		19
20	Acid phosphate, 160; muriate potash, 100; nitrate soda, 80	188.97	33.03	193.64	41.14	184.72	32.04	194.95	43.01	20
21	Same elements as 20, but nitrogen in oilmeal	182.89	26.44	180.88	28.35	178.56	24.42	184.70	32.26	21
22	None	159.96		152.23		155.62		152.94		22
23	Same elements as 20, but nitrogen in dried blood	181.55	27.93	170.84	15.89	178.22	25.39	187.20	35.56	23
24	Same elements as 20, but nitrogen in sulphate ammonia	176.03	25.75	180.87	32.52	175.62	25.56	185.61	31.27	24
25	None	146.94		159.91		147.28		155.03		25
26	Same elements as 11, but phosphorus in bonemeal	164.92	14.37	182.55	25.55	167.45	16.18	175.12	21.87	26
27	Same elements as 11, but phosphorus in dissolved boneblack	170.93	18.57	190.98	36.88	174.68	19.39	190.34	38.86	27
28	None	153.08		151.20		159.24		149.70		28
29	Same elements as 11, but phosphorus in basic slag	169.69	15.89	177.63	22.64	171.94	14.43	183.29	26.84	29
30	Yard manure, 8 tons on potatoes only	179.25	26.73	197.02	38.84	185.33	25.55	204.10	40.91	30
31	None	151.24		162.58		154.04		169.94		31
32	Yard manure, 16 tons on wheat only	*177.51	*15.45	199.63	35.21	*167.83	*16.47	200.18	38.02	32
33	Same elements (since 1899) as 20, but nitrogen in tankage	1167.31	117.25	194.50	38.70	1166.69	113.31	195.48	41.12	33
34	None	1145.55		157.64		1148.87		146.58		34
Average unfertilized yield		154.74		165.81		154.63		166.54		

* Three years. † Five years.

TABLE XIII. YIELD AND INCREASE PER ACRE OF WHEAT IN POTATOES-WHEAT-CLOVER ROTATION, 1908 AND 14 YEARS, 1895-1908.

Plot		Fertilizing materials		1908				14 years, 1894-1908				Plot	
No.	Pounds per acre	Yield			Increase		Yield		Increase		Straw	Plot	
		Grain	Straw	Lbs.	Grain	Straw	Grain	Straw					
1	None	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	Bus.	Lbs.	No.	
2	Acid phosphate, 160.	41.92	4,165	...	...	30.91	3,142	...	...	...	...	1	
3	Muriate potash, 100.	51.67	5,130	9.90	983	36.35	3,743	...	...	5.60	657	2	
4	None	45.46	4,072	3.35	-38	32.68	3,005	...	...	2.05	-24	3	
5	Nitrate soda, 160.	42.46	4,092	...	...	30.50	2,973	...	...	...	...	4	
6	Acid phosphate, 160; dried blood, 50; nitrate soda, 120.	39.08	4,035	-92	249	30.73	3,200	...	...	92	2988	5	
7	None	46.21	4,697	8.67	1,216	36.42	3,814	...	...	7.31	983	6	
8	Acid phosphate, 160; muriate potash, 100.	35.08	3,175	...	...	28.41	2,759	...	...	...	...	7	
9	Muriate potash, 100; dried blood, 50; nitrate soda, 120.	47.17	4,150	10.49	824	36.06	3,350	...	...	7.26	596	8	
10	None	39.67	3,770	1.40	294	34.45	3,216	...	...	5.27	468	9	
11	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 120	39.87	3,627	...	...	29.57	2,742	...	...	...	...	10	
12	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 200	50.42	4,765	11.15	1,164	38.61	3,720	...	...	9.29	1,003	11	
13	None	48.08	4,545	9.40	1,069	38.38	3,583	...	...	9.31	1,161	12	
14	Acid phos., 320; mur. potash, 200. dried blood, 50; nit. soda, 120	38.08	3,550	...	...	28.81	2,666	...	...	...	...	13	
15	Fertilized on potatoes only	47.67	4,890	10.41	1,529	38.98	3,802	...	...	10.00	1,208	14	
16	None	48.50	4,970	12.06	1,039	36.79	3,516	...	...	9.05	995	15	
17	Yard manure, 4 tons	35.62	2,982	...	...	27.21	2,449	...	...	...	...	16	
18	Yard manure, 8 tons.	43.21	4,427	10.30	1,396	31.33	3,051	...	...	5.03	624	17	
19	None	48.67	4,680	14.46	1,599	32.51	3,128	...	...	7.13	724	18	
20	Acid phos., 160; mur. potash, 100; dried blood, 25; nit. soda, 60	33.50	3,130	...	...	24.46	2,382	...	...	...	...	19	
21	Same elements as 20, but nitrogen in oilmeal.	49.83	4,510	17.33	1,627	33.96	3,295	...	...	9.62	982	20	
22	None	45.67	3,920	14.17	1,283	34.12	3,198	...	...	9.90	949	21	
23	Same elements as 20, but nitrogen in dried blood.	30.50	2,390	...	...	24.10	2,183	...	...	...	...	22	
24	Same elements as 20, but nitrogen in sulphate ammonia.	45.25	3,485	14.07	959	34.88	3,221	...	...	10.57	1,008	23	
25	None	48.71	3,957	16.85	1,296	34.84	3,192	...	...	10.32	947	24	
26	Same elements as 11, but phosphorus in bonemeal.	32.54	2,797	...	...	24.73	2,274	...	...	...	...	25	
27	Same elements as 11, but phosphorus in dissolved boneblack.	47.04	4,127	15.18	1,309	35.64	3,351	...	...	10.85	1,025	26	
28	None	49.17	4,330	17.99	1,551	36.95	3,631	...	...	12.12	1,253	27	
29	Same elements as 11, but phosphorus in basic slag	30.50	2,800	...	...	24.88	2,429	...	...	...	...	28	
30	Manured on potatoes.	48.67	4,580	17.88	1,468	37.61	3,736	...	...	12.75	1,315	29	
31	None	44.37	3,967	13.29	1,002	31.85	3,087	...	...	7.02	674	30	
32	Yard manure, 16 tons.	31.37	3,017	...	...	24.81	2,405	...	...	...	...	31	
33	Same elements as 20, but nitrogen in tankage.	49.50	4,680	17.99	1,758	38.80	3,849	...	...	11.18	1,213	32	
34	None	47.58	3,765	15.93	978	38.75	3,570	...	...	11.48	1,009	33	
Average unfertilized yield		35.27	3,331	...	...	26.53	2,542	...	...	...	...	34	

TABLE XIV. YIELD AND INCREASE PER ACRE OF WHEAT IN POTATOES-WHEAT-CLOVER ROTATION BY PERIODS.

Plot		Fertilizing materials	1895-1900				1901-1906			
			Grain		Straw		Grain		Straw	
			Yield	Increase	Yield	Increase	Yield	Increase	Yield	Increase
No.	Pounds per acre	Bus.	Bus.	Lbs.	Lbs.	Bus.	Bus.	Lbs.	Lbs.	No.
1	None	24.24	3.78	2,585	356	34.72	7.25	3,543	935	1
2	Acid phosphate, 160.	27.93	2.84	2,889	65	41.64	1.66	4,365	-56	2
3	Muriate potash, 100.	26.90		2,546		35.73		3,261		3
4	None	23.96		2,429		33.75		3,204		4
5	Nitrate soda, 160.	25.72	1.68	2,740	323	33.21	.66	3,440	298	5
6	Acid phosphate, 160; dried blood, 50; nitrate soda, 120.	30.50	6.37	3,135	730	39.67	7.93	4,261	1,179	6
7	None	24.21		2,392		30.73		3,021		7
8	Acid phosphate, 160; muriate potash, 100.	31.07	6.64	2,870	500	39.11	8.10	3,670	692	8
9	Muriate potash, 100; dried blood, 50; nitrate of soda, 120.	30.57	5.90	2,737	389	36.60	5.30	3,464	529	9
10	None	24.90		2,326		31.88		2,893		10
11	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 120	32.60	7.67	3,075	752	41.97	10.81	4,047	1,169	11
12	Acid phos., 160; mur. potash, 100; dried blood, 50; nit. soda, 200	33.36	8.40	3,205	886	40.94	10.21	4,145	1,283	12
13	None	24.98		2,316		30.30		2,847		13
14	Acid phos., 320; mur. potash, 200; dried blood, 50; nit. soda, 120	34.53	9.83	3,285	987	40.07	10.67	4,086	1,323	14
15	Fertilized on potatoes only	33.01	8.60	3,053	773	38.92	10.42	3,886	1,308	15
16	None	24.13		2,260		27.60		2,444		16
17	Yard manure, 4 tons.	25.43	2.84	2,454	296	33.24	6.48	3,301	826	17
18	Yard manure, 8 tons.	26.32	4.27	2,479	423	34.55	8.63	3,307	802	18
19	None	21.00		1,954		25.07		2,536		19
20	Acid phos., 160; mur. potash, 100; dried blood, 25; nit. soda, 60	26.25	5.34	2,483	558	37.98	12.92	3,676	1,234	20
21	Same elements as 20, but nitrogen in oilmeal.	28.95	8.13	2,636	741	36.74	11.67	3,534	1,191	21
22	None	20.72		1,865		25.06		2,251		22
23	Same elements as 20, but nitrogen in dried blood	29.46	8.70	2,734	852	37.87	12.47	3,559	1,276	23
24	Same elements as 20, but phosphorus in sulphate ammonia	29.72	8.92	2,733	838	36.82	11.09	3,418	1,097	24
25	None	20.84		1,918		26.06		2,515		25
26	Same elements as 11, but phosphorus in bonemeal.	30.41	9.33	2,915	953	38.16	12.21	3,485	1,075	26
27	Same elements as 11, but phosphorus in dissolved boneblack.	31.23	9.92	2,981	974	39.74	13.89	3,999	1,535	27
28	None	21.55		2,052		25.73		2,518		28
29	Same elements as 11, but phosphorus in basic slag	32.23	10.80	3,094	1,062	39.91	14.21	4,074	1,535	29
30	Manured on potatoes	25.78	4.47	2,348	335	34.91	9.22	3,501	941	30
31	None	21.18		1,994		25.66		2,580		31
32	Yard manure, 16 tons.	37.73	9.89	3,556	976	37.39	11.74	3,812	1,291	32
33	Same elements as 20, but nitrogen in tankage.	27.83	10.95	3,377	905	37.62	11.99	3,684	1,133	33
34	None.	23.92		2,357		25.63		2,402		34
Average unfertilized yield		22.62		2,158		28.49		2,716		

TABLE XV. YIELD AND INCREASE PER ACRE OF CLOVER IN POTATOES-WHEAT-CLOVER ROTATION, 1908,
13 YEARS, 1896-1908, AND BY 6-YEAR PERIODS.

Plot	Total fertilizing materials applied to previous crops of rotation. None on clover.										1908		13 years, 1896-1908		6 years, 1896-1901		6 years, 1902-1907		Plot		
	Pounds per acre										Increase		Yield		Increase		Yield			Increase	
											Yield		Lbs.		Yield		Lbs.			Yield		Lbs.		Yield		Lbs.
No.											Lbs.		Lbs.		Lbs.		Lbs.		Lbs.		No.
1	None										3,250		3,606		4,183		4,535		4,535		1
2	Acid phosphate, 320.										4,110	747	3,835	353	4,412		4,898		4,898		2
3	Muriate potash, 200.										3,860	383	3,447	87	4,051	107	3,865	18	3,865		3
4	None										3,590		3,237		3,824		3,651		3,651		4
5	Nitrate soda, 200; dried blood, 50.										4,330	467	3,469	231	4,019	149	3,851	251	3,851		5
6	Acid phosphate, 320; nitrate soda, 200; dried blood, 50.										5,250	1,113	3,667	369	4,041	126	3,960	417	3,960		6
7	None										4,410		3,330		3,960		3,786		3,786		7
8	Acid phosphate, 320; muriate potash, 200.										4,260	187	3,542	301	4,116	151	3,976	304	3,976		8
9	Muriate potash, 200; nitrate soda, 200; dried blood, 50.										5,260	1,523	3,610	456	4,248	280	3,976	574	3,976		9
10	None										3,400		3,066		3,972		3,839		3,839		10
11	Acid phos., 320; mur. potash, 200; nit. soda, 200; dried blood, 50.										5,500	1,857	3,492	373	3,888	-79	3,839	451	3,839		11
12	Acid phos., 320; mur. potash, 200; nit. soda, 300; dried blood, 50.										5,480	1,583	3,664	492	4,109	147	4,047	591	4,047		12
13	None										4,130		3,228		3,957		3,502		3,502		13
14	Acid phos., 480; mur. potash, 300; nit. soda, 280; dried blood, 50.										5,680	1,577	3,698	555	3,874	18	4,187	746	4,187		14
15	Acid phos., 480; mur. potash, 300; nitrate soda, 320.										5,970	1,893	3,697	635	4,062	306	4,001	630	4,001		15
16	None										4,050		2,981		3,656		3,316		3,316		16
17	Yard manure, 4 tons on wheat.										5,380	1,573	3,483	610	4,011	397	3,913	691	3,913		17
18	Yard manure, 8 tons on wheat.										5,850	2,287	3,858	1,093	4,401	829	4,155	1,059	4,155		18
19	None										3,320		2,956		3,530		2,986		2,986		19
20	Acid phos., 320; mur. potash, 200; nit. soda, 140; dried blood, 25.										5,040	1,610	3,435	734	4,163	630	3,689	664	3,689		20
21	Same elements as 20, but nitrogen in oilmeal.										5,320	1,980	3,119	373	3,826	292	3,218	155	3,218		21
22	None										3,650		2,791		3,537		3,101		3,101		22
23	Same elements as 20, but nitrogen in dried blood.										5,130	1,583	3,138	376	3,412	-74	3,671	495	3,671		23
24	Same elements as 20, but nitrogen in sulphate ammonia.										5,330	1,887	3,130	396	3,437	1	3,607	456	3,607		24
25	None										3,340		2,705		3,326		3,226		3,226		25
26	Same elements as 11, but phosphorus in bonemeal.										5,660	2,033	3,424	654	3,628	213	4,039	702	4,039		26
27	Same elements as 11, but phosphorus in dissolved boneblack.										5,240	1,327	3,252	417	3,506	63	3,817	472	3,817		27
28	None										4,200		2,900		3,474		3,355		3,355		28
29	Same elements as 11, but phosphorus in basic slag.										5,650	1,663	3,714	861	4,175	756	4,078	740	4,078		29
30	Yard manure, 8 tons on potatoes.										5,360	1,587	3,697	890	3,983	619	4,242	905	4,242		30
31	None										3,560		2,761		3,309		3,328		3,328		31
32	Yard manure, 16 tons on wheat.										6,350	3,237	3,453	1,263	3,801	742	4,979	1,673	4,979		32
33	Same elements as 20, but nitrogen in tankage.										5,030	2,363	2,651	444	3,378	241	3,840	355	3,840		33
34	None										2,220		2,223		3,125		3,564		3,564		34
Average unfertilized yield											3,014		3,692		3,692		3,443		3,443		

BARNYARD MANURE TEST.

COMPARISON OF YARD WITH FRESH MANURE.

THE REINFORCEMENT OF MANURE.

This experiment was begun in 1897 for the purpose of comparing manure which has lain for some months in an open barnyard with that taken directly from the stable to the field, and of studying the effect of treating the manure with several absorbent or reinforcing materials.

In this investigation a lot of manure has been taken from the open barnyard, where it has been accumulating during the winter and divided into four parcels. With one parcel is mixed the finely ground, phosphatic rock, known as floats, from which acid phosphate is made by mixing it with sulphuric acid; with another parcel acid phosphate is mixed; with a third, the crude potash salt, known as kainit, and with a fourth, land plaster or gypsum; the reinforcing materials being used at the uniform rate of 40 pounds per ton of manure. At the same time manure taken from box stalls, where it has accumulated under the feet of animals kept continuously in their stalls, is divided into similar parcels and treated with like quantities of the same materials.

After a few weeks the manure thus treated, together with two lots of untreated manure, one taken from the yard and one from the stable, is spread upon clover sod at the rate of eight tons per acre and plowed under for corn, the corn being followed by wheat and clover in a 3-year rotation. During the first three seasons Soy beans were grown, because of clover failure, and were plowed under.

Three tracts of land, A, B and C, are included in the test, each crop being grown every season. The arrangement of these tracts and the plan of fertilizing are shown in Diagram V.

DIAGRAM V: ARRANGEMENT OF PLOTS AND PLAN OF FERTILIZING IN
EXPERIMENTS WITH MANURE.

PLOTS ONE-SIXTEENTH ACRE.

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

SECTION A.

1	Nothing
2	Yard manure and floats
3	Stall manure and floats
4	Nothing
5	Yard manure and acid phos.
6	Stall manure and acid phos.
7	Nothing
8	Yard manure and kainit
9	Stall manure and kainit
10	Nothing

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

SECTION B.

1	Nothing
2	Yard manure and floats
3	Stall manure and floats
4	Nothing
5	Yard manure and acid phos.
6	Stall manure and acid phos.
7	Nothing
8	Yard manure and kainit
9	Stall manure and kainit
10	Nothing

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

SECTION C.

1	Nothing
2	Yard manure and floats
3	Stall manure and floats
4	Nothing
5	Yard manure and acid phos.
6	Stall manure and acid phos.
7	Nothing
8	Yard manure and kainit
9	Stall manure and kainit
10	Nothing

NORTH

TABLE XVI. BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION. AVERAGE YIELD PER ACRE 1908, AND 12 YEARS 1897-1908.

Plot No.	Manure and treatment	1908					12 years, 1897-1908					Plot No.
		Corn, Section B		Wheat, Section C		Hay Lbs.	Corn		Wheat 11 years		Hay 8 years Lbs.	
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.		
Yield per acre.												
1	None.....	28.11	1,840	18.67	2,000	2,435	37.15	2,222	12.14	1,477	2,372	1
2	Yard manure and floats.....	65.88	3,280	33.20	3,384	4,711	59.42	3,313	25.03	2,696	3,791	2
3	Stall manure and floats.....	66.86	2,992	32.47	3,476	5,066	63.31	3,069	26.42	2,887	4,389	3
4	None.....	26.97	2,000	11.47	1,552	1,902	31.03	2,009	10.35	1,226	1,787	4
5	Yard manure and acid phosphate.....	67.03	3,264	32.20	3,716	4,391	60.27	3,276	25.33	2,716	3,543	5
6	Stall manure and acid phosphate.....	63.09	2,784	32.47	3,588	5,242	64.38	3,471	26.18	2,871	4,341	6
7	None.....	23.14	1,680	11.93	1,572	1,475	30.83	1,970	9.67	1,157	1,696	7
8	Yard manure and kaint.....	59.71	3,120	25.67	3,036	3,413	54.63	3,154	21.31	2,394	2,984	8
9	Stall manure and kaint.....	59.77	2,944	27.20	3,136	5,102	60.07	3,495	23.35	2,701	3,885	9
10	None.....	36.00	1,968	8.87	1,164	1,137	32.89	2,003	10.29	1,208	1,906	10
11	Yard manure and gypsum.....	60.51	1,728	18.53	2,296	1,955	36.83	2,333	13.07	1,616	2,593	11
12	Stall manure and gypsum.....	60.51	2,784	29.07	3,048	3,413	57.98	3,364	23.44	2,645	3,268	12
13	None.....	61.71	2,624	27.07	3,048	4,160	60.66	3,550	23.27	2,619	3,295	13
14	Yard manure, untreated.....	21.43	1,712	12.40	1,464	1,902	31.57	2,007	9.86	1,137	1,698	14
15	Stall manure, untreated.....	57.31	2,640	24.40	2,536	3,537	51.17	2,886	18.76	2,281	3,269	15
16	None.....	57.83	2,576	26.60	2,724	4,575	58.16	3,304	20.35	2,113	3,269	16
17	Chemical fertilizer*.....	38.80	2,176	13.07	1,536	2,061	36.55	2,303	10.21	1,562	2,717	17
18	Chemical fertilizer†.....	49.43	2,688	20.67	2,104	2,844	43.12	2,587	13.42	1,762	2,860	18
19	None.....	56.34	2,592	20.13	2,056	2,886	44.37	2,456	14.91	1,762	2,860	19
20	Average unmanured yield.....	33.49	1,920	9.07	1,232	2,066	34.09	2,025	9.98	1,248	2,197	20
		29.53	1,878	13.00	1,602	1,867	33.87	2,108	10.67	1,991	1,255	

* Acid phosphate, 80 lbs., muriate potash, 80 lbs., nitrate soda, 160 lbs.

† Acid phosphate, 80 lbs., muriate potash, 10 lbs., tankage (7-30) 100 lbs.

The table shows that in 1908 the difference in effect between the yard and stall manure and between the two phosphates was smaller than the average, but this has usually been the case when corn and wheat were grown on these two sections.

TABLE XVII. BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION.
INCREASE PER ACRE 12 YEARS, 1897-1908.

Plot No.	Manure and treatment	12 years, 1897-1908				
		Corn		Wheat		Hay Lbs.
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	
Increase per acre.						
2	Yard manure and floats.....	24.31	1,162	13.49	1,302	1,614
3	Stall manure and floats.....	30.24	1,485	15.48	1,577	2,407
5	Yard manure and acid phosphate.....	29.30	1,280	15.21	1,513	1,786
6	Stall manure and acid phosphate.....	33.48	1,487	16.29	1,692	2,614
8	Yard manure and kainit.....	23.11	1,172	11.43	1,220	1,217
9	Stall manure and kainit.....	27.86	1,503	13.27	1,510	2,048
12	Yard manure and gypsum.....	22.90	1,139	11.45	1,189	973
13	Stall manure and gypsum.....	27.34	1,434	12.34	1,323	1,299
15	Yard manure, untreated.....	17.94	781	8.78	942	754
16	Stall manure, untreated.....	23.27	1,101	10.26	1,076	1,376
18	Chemical fertilizer*.....	7.39	377	3.28	320	657
19	Chemical fertilizer†.....	9.46	337	4.85	517	731

TABLE XVIII. BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION.
AVERAGE VALUES OF TOTAL YIELD AND OF INCREASE.

Plot No.	Manure and treatment	Cost of treat- ment	Value of total yield per acre		Value of increase		
			Total	Net	Total per acre	Net per acre	Net per ton manure
2	Yard manure and floats.....	\$1.40	\$66.62	\$65.22	\$30.02	\$28.62	\$3.58
3	Stall manure and floats.....	1.40	72.25	70.85	37.91	36.51	4.56
5	Yard manure and acid phosphate..	2.40	66.17	63.77	34.46	32.06	4.01
6	Stall manure and acid phosphate...	2.40	72.14	69.74	40.80	38.40	4.80
8	Yard manure and kainit.....	2.70	57.96	55.26	26.23	23.53	2.94
9	Stall manure and kainit.....	2.70	66.13	63.49	33.72	31.02	3.88
12	Yard manure and gypsum.....	1.00	62.71	61.71	25.11	24.11	3.01
13	Stall manure and gypsum.....	1.00	64.00	63.00	29.48	28.48	3.56
15	Yard manure, untreated.....	....	52.12	52.12	19.33	19.33	2.42
16	Stall manure, untreated.....	....	59.86	59.86	25.75	25.75	3.22

The financial outcome of this test is shown in Table XVIII, in which the materials used in treatment are re-valued in accordance with present prices.

It will be observed that the average increase produced by the ton of stall manure has in every case been greater than that from the ton of yard manure similarly treated, and that the ton of stall manure treated with acid phosphate has produced nearly double the increase recovered from the ton of untreated yard manure.

While the treatment of manure has in every case increased its effectiveness, the gain per acre produced by reinforcing the manure with acid phosphate has apparently been so much greater than that from any other treatment that it has not been profitable to use anything else, even though the other materials had cost nothing.

It is true that the average total yield of the two plots receiving manure treated with floats has been so nearly the same as that of the plots dressed with manure treated with acid phosphate, that when the difference in cost of the reenforcing materials is taken into consideration the net totals following the floats treatment are slightly greater than those following the acid phosphate, the apparently greater increase on the acid phosphate plots being due to the relatively large yields of the unmanured plots, 1 and 11; but a careful study of the land on which this test is located leads us to believe that the variation in yield between these plots and the next unmanured plots, 4 and 14, is due to a progressive variation in the soil, and that the true method of comparison is the one which we have followed.

In Table XIX the results of this test are arranged in periods, as has been done in the experiments reported in the preceding pages, in order to show the cumulative effect of the fertilizers and manures.

TABLE XIX. BARNYARD MANURE ON CROPS GROWN IN ROTATION. YIELD AND INCREASE PER ACRE BY PERIODS.

Plot No.	Manure and treatment	First period				Second period				Plot No.							
		Corn, 1897-1902		Wheat, 1898-1903		Hay 1901-1904		Corn, 1903-1908			Wheat, 1904-1908		Hay 1905-1908				
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Stover Lbs.		Grain Bus.	Stover Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Stover Lbs.
		Yield per acre.															
1	None	41.63	1,983	9.74	1,050	2,072	32.68	2,461	15.02	1,990	2,672	1					
2	Yard manure and floats	60.22	2,957	22.39	2,195	3,416	58.61	3,669	28.20	3,297	4,167	2					
3	Stall manure and floats	62.68	3,114	24.28	2,431	3,908	63.95	4,016	29.00	3,434	4,871	3					
4	None	37.77	1,909	8.45	1,604	1,604	24.30	2,109	12.63	1,583	1,971	4					
5	Yard manure and acid phosphate	63.46	3,908	21.50	2,075	3,028	59.08	3,644	29.93	3,484	4,069	5					
6	Stall manure and acid phosphate	63.46	3,127	23.37	2,336	3,803	65.30	3,814	29.55	3,514	4,878	6					
7	None	37.66	1,797	7.19	1,315	1,315	22.51	2,143	12.64	1,822	2,077	7					
8	Yard manure and kaimit	58.99	2,918	18.50	1,836	2,362	50.26	3,389	24.68	3,063	3,605	8					
9	Stall manure and kaimit	61.05	3,105	20.99	2,167	3,092	54.08	3,885	26.19	3,411	4,678	9					
10	None	41.54	2,020	8.41	1,823	1,560	24.24	1,987	12.55	1,570	2,251	10					
11	Yard manure and gypsum	41.00	2,228	11.05	1,136	2,276	32.67	2,439	13.49	1,911	2,691	11					
12	Stall manure and gypsum	60.88	3,024	21.90	2,164	2,880	55.08	3,703	25.30	3,222	3,637	12					
13	None	39.03	3,270	22.54	2,223	2,692	24.11	3,829	12.79	3,095	3,890	13					
14	Yard manure, untreated	55.00	2,666	7.43	1,786	1,406	24.11	2,118	12.79	1,539	1,990	14					
15	Stall manure, untreated	59.20	2,966	15.63	1,579	1,952	47.36	3,107	22.52	2,734	3,148	15					
16	None	40.71	2,006	7.85	1,803	2,496	32.39	3,643	23.67	2,955	4,043	16					
17	Chemical fertilizer*	47.96	2,358	10.46	1,087	1,824	38.27	2,816	16.99	1,575	2,159	17					
18	Chemical fertilizer†	49.47	2,342	11.88	1,196	2,344	39.27	2,670	18.54	2,133	3,266	18					
19	None	41.48	2,007	7.93	1,898	1,768	26.70	2,043	12.46	2,441	3,376	19					
	Average unmanured yield	40.10	1,979	8.51	898	1,678	27.63	2,237	13.26	1,683	2,305						
		Increase per acre.															
2	Yard manure and floats	19.88	998	13.08	1,214	1,500	28.75	1,326	13.98	1,409	1,729	2					
3	Stall manure and floats	23.62	1,181	15.39	1,518	2,148	36.86	1,790	15.38	1,649	2,067	3					
5	Yard manure and acid phosphate	23.72	1,037	13.46	1,256	1,520	34.88	1,523	17.30	1,821	2,503	5					
6	Stall manure and acid phosphate	25.76	1,293	15.76	1,543	2,392	41.19	1,682	17.43	1,873	2,836	6					
8	Yard manure and kaimit	20.03	1,046	10.90	1,050	966	26.18	1,298	12.07	1,425	1,469	8					
9	Stall manure and kaimit	20.81	1,159	12.99	1,362	1,847	34.91	1,847	13.61	1,687	2,454	9					
12	Yard manure and gypsum	20.53	907	12.06	1,145	894	25.27	1,371	10.72	1,242	1,053	12					
13	Stall manure and gypsum	23.80	1,264	13.90	1,320	996	30.87	1,604	10.46	1,326	1,601	13					
15	Yard manure, untreated	15.39	734	8.06	1,764	406	20.50	828	9.65	1,157	1,102	15					
16	Stall manure, untreated	19.04	997	9.88	958	811	27.49	1,204	10.71	1,157	1,102	16					
18	Chemical fertilizer*	6.99	351	2.58	204	363	7.78	1,402	4.13	1,218	1,941	18					
19	Chemical fertilizer†	8.99	335	3.98	306	557	10.68	339	5.89	460	903	19					

* Acid phosphate, 80 lbs.; muriate potash, 160 lbs.

† Acid phosphate, 70 lbs.; muriate potash, 100 lbs.; tankage (7.30) 100 lbs.

An analysis of Table XIX brings out the following points: The unmanured yield of corn has fallen off during the second period, as compared with the first; the yields of all the plots dressed with yard manure are also smaller during the second period; the plots dressed with untreated stall manure, or with stall manure treated with gypsum or kainit, also give smaller yields during the second period, while those receiving stall manure reenforced with floats or acid phosphate show larger yields for the second period. The reduction in yield on the manured plots, however, is much less than on those receiving no manure, consequently the increase from the manures is invariably greater during the second period.

The wheat crop shows a general gain in yield on both manured and unmanured land during the second period, due in part, at least, to the fact that it suffered from an attack of Hessian fly and from more unfavorable winter conditions during the first period.

The increase of wheat from the untreated manure and from all the treatments, except with gypsum, is greater during the second period, but the rate of increase after acid phosphate is greater than that after floats or kainit.

The hay shows a larger increase on all the land during the second period, but this is partly due to the fact that the use of lime was begun during this period, the lime being applied to all the land, both manured and unmanured, other experiments having shown that the addition of lime to this soil is absolutely necessary before manure or fertilizers can produce their full effect.

SUMMARY.

In the case of the crops grown continuously on the same land there has been a rapid falling off in yield during recent years on the unfertilized land, whereas there has been a slight increase in yield on similar land when the same crops have been grown in rotation with each other and with clover. A given quantity of manure or fertilizer, moreover, has produced a smaller increase on crops grown continuously than on those grown in rotation.

In the 5-year rotation of corn, oats, wheat, clover and timothy, the unfertilized yield of corn has remained practically stationary throughout the 15 years of the test; that of oats has been slightly larger during the last five years than previously, and that of wheat decidedly larger, this gain in wheat yield being due chiefly to greater immunity to insect attack during the latter period. The average increase per acre in all the cereal crops has been very much greater during the latter period than formerly, due to the cumulative effect on the fertilizers and manure.

As between chemical fertilizers and open-yard manure, the manure has shown the greater increase in effectiveness during the later years of the test.

On both the thin land on which this 5-year test is located and on the richer soil used in the 3-year rotation of potatoes, wheat and clover the greatest total yield and the greatest net gain after deducting the cost of the fertilizer, have been produced by complete fertilizers, carrying nitrogen in nitrate of soda, phosphorus in acid phosphate and potassium in muriate of potash. The experiments, however, demonstrate the practicability of replacing the nitrogen and potassium with stable manure, thus greatly diminishing the cost of fertilizing and increasing the net gain.

The experiments with manure forcibly demonstrate the importance of avoiding the waste to which manure is subjected while lying in open barnyards and of reenforcing manure with some carrier of phosphorus, to replace the phosphorus carried away in the bones of live stock, in milk, and in the grains which are sold off the farm.

INDEX.

Fertilizers on crops grown continuously.....	3
The 5-year rotation.....	6
Plan of fertilizing in 5-year rotation.....	7
Corn in 5-year rotation.....	8
Oats in 5-year rotation.....	10
Wheat in 5-year rotation.....	12
Clover and timothy in 5-year rotation.....	14
Financial outcome of 5-year rotation	16
The potatoes-wheat-clover rotation... ..	17
Plan of fertilizing in potatoes-wheat-clover rotation.....	18
Potatoes in potatoes-wheat-clover rotation.....	20
Wheat in potatoes-wheat-clover rotation.....	22
Clover in potatoes-wheat-clover rotation.....	24
Barnyard manure test, The.....	25
Barnyard manure test, Financial outcome.....	28

Ohio Agricultural Experiment Station.

CIRCULAR No. 93.

WOOSTER, OHIO, APRIL 15, 1909.

CARRIERS OF PHOSPHORUS IN FERTILIZERS

BY CHAS. E. THORNE

The chief sources from which the phosphorus of commercial fertilizers is derived are acid phosphate on the one hand and bone meal or other animal refuse on the other. Acid phosphate, known in England as superphosphate, is made by mixing together approximately equal weights of the phosphatic rock, found in Tennessee, Florida and South Carolina, and sulphuric acid, the object of adding the acid being to produce a chemical action by which the almost insoluble rock is converted into a form soluble in water or in very dilute acids. The rock is first ground to a very fine powder, called floats; this is mixed with sulphuric acid, the mixture is allowed to stand for some time when it becomes caked, it is then reground and sold, sometimes simply as acid phosphate, more often under some proprietary name, as "Dissolved Bone," "Wheat Special," "XXX Phosphate," etc., etc. Any fertilizing material, which is claimed to contain only phosphoric acid; of which 10 to 16 percent is classed as "available" and 1 to 3 percent as "insoluble" may be set down as an acid phosphate.

The term "phosphoric acid" is a misnomer, as the acidity of an acid phosphate is due to the sulphuric acid of the fertilizer, and not to the combination of phosphorus with oxygen formerly named "phosphoric acid," but now more correctly called phosphorus pent-oxide.

Bonemeal is sold as "pure raw bonemeal," which should analyze 3 to 5 percent "ammonia" and 20 to 24 percent "phosphoric acid," and as "steamed bonemeal," analyzing 1 to 3 percent "ammonia" and 20 to 27 percent "phosphoric acid," both grades varying occasionally from these figures.

A third bone fertilizer, formerly much more in use than at present, was made by treating bone charcoal which had been used in refining sugar, oil etc., with sulphuric acid, making what is known as "dissolved boneblack," a material closely approximating acid phosphate in composition.

In addition to these carriers of phosphorus the untreated, ground phosphate rock, or "floats," is offered for fertilizing purposes, and also a fourth material known here as Basic Slag, and in Europe as "Thomas Phosphate Powder." This substance is a by-product of the manufacture of steel by the Basic or Thomas-Gilchrist process, a process by which the phosphorus of phosphatic iron ores is caused to unite with the furnace slag, which is then ground into a fine powder. Basic slag phosphate is not now being manufactured in this country, our entire supply coming from Europe.

While located at Columbus, this Station began a comparison of dissolved boneblack, acid phosphate and basic slag as carriers of phosphorus; these materials being used in combination with nitrate of soda and muriate of potash, the fertilizers being so compounded as to carry equal weights each of phosphorus, potassium and nitrogen. The fertilizers were used on crops grown in continuous culture, with the following outcome:

TABLE I:—CARRIERS OF PHOSPHORUS ON CROPS GROWN IN CONTINUOUS CULTURE AT COLUMBUS, 1888--1902

Carriers of phosphorus	Increase per acre					
	Corn 13-year average		Oats 8-year average		Wheat 12-year average	
	Grain	Stover	Grain	Straw	Grain	Straw
	Bus	lbs	Bus	lbs	Bus	lbs
Dissolved boneblack.....	6.42	390	6.21	434	5.93	1,144
Acid phosphate.....	8.29	678	6.58	537	4.22	673
Basic slag.....	7.78	499	6.58	496	5.14	697

In the case of the wheat crop the fertilizers were discontinued after the eighth season, but the yields were separately ascertained for six years longer. In 1896 and 1900 the wheat was totally destroyed in this experiment by Hessian fly and winter killing, and the averages are computed for 12 years.

On the removal of the Station to Wooster this comparison was begun again, but this time on crops grown in rotation instead of in continuous culture—the 5-year cereal rotation of corn, oats, wheat, clover and timothy, begun at Wooster in 1894 and at Strongsville in 1895, and the 3-year rotation of potatoes, wheat and clover begun at Wooster in 1894. Bonemeal was added to the test in each case and the phosphates were used in complete fertilizers, made up to contain equal weights of nitrogen, phosphorus and potassium, acid phosphate being used on the basis of 14 percent available phosphoric acid and dissolved boneblack on

that of 16 percent, while bonemeal was reckoned as containing the equivalent of 20 percent "available" phosphoric acid and basic slag as containing the equivalent of 17 percent total phosphoric acid. The general results of this comparison are shown in Table II, which gives the total yield per acre from each of the different applications and the increase over the unfertilized yield.*

TABLE II:—COMPARISON OF CARRIERS OF PHOSPHORUS.
TOTAL YIELD AND INCREASE PER ACRE

Plot No	Carrier	Corn		Oats		Wheat		Hay	
		Grain Bus	Stover lbs	Grain Bus	Straw lbs	Grain Bus	Straw lbs	Clover lbs	Timothy lbs
5-year cereal rotation: Wooster: 15-year average total yield per acre									
11	Acid phosphate.....	48.44	2,273	49.86	2,155	27.03	2,846	3,123	3,620
26	Bonemeal.....	46.91	2,319	46.71	1,970	23.49	2,372	3,293	3,677
27	Dissolved boneblack.....	48.22	2,307	49.35	2,163	26.36	2,639	2,893	3,488
29	Basic slag.....	49.33	2,410	47.42	2,012	24.61	2,518	3,064	3,835
5-year cereal rotation: Wooster: 15-year average increase per acre									
11	Acid phosphate.....	18.07	668	18.33	901	16.30	1,766	1,317	1,058
26	Bonemeal.....	14.18	542	14.98	673	12.69	1,282	1,468	949
27	Dissolved boneblack.....	14.73	501	17.22	881	15.65	1,589	1,023	683
29	Basic slag.....	15.09	576	14.90	744	13.98	1,506	1,148	952
5-year cereal rotation: Strongsville: 14-year average total yield per acre									
11	Acid phosphate.....	37.33	1,920	50.93	2,013	18.43	1,765	2,496	2,659
26	Bonemeal.....	34.62	1,934	47.66	1,826	19.44	1,763	2,614	2,356
27	Dissolved boneblack.....	33.87	1,869	48.42	1,846	18.37	1,700	2,278	1,970
29	Basic slag.....	35.34	1,896	46.93	1,775	19.58	1,808	2,342	2,269
5-year cereal rotation: Strongsville: 14-year average increase per acre									
11	Acid phosphate.....	11.76	439	13.93	583	10.61	1,026	821	482
26	Bonemeal.....	8.84	339	12.20	469	11.69	1,047	925	460
27	Dissolved boneblack.....	8.90	304	13.59	559	10.50	970	638	148
29	Basic slag.....	10.95	360	13.16	539	11.85	1,090	762	502
3-year potato rotation: Wooster: 15-year average yield and increase per acre									
Plot No	Carrier	Potatoes		Wheat				Clover	
		Yield Bus	Increase Bus	Yield		Increase		Yield lbs	Increase lbs
				Grain Bus	Straw lbs	Grain Bus	Straw lbs		
11	Acid phosphate.....	184.08	24.18	38.61	3,720	9.29	1,003	3,492	373
26	Bonemeal.....	176.48	28.31	35.64	3,351	10.85	1,025	3,424	654
27	Dissolved boneblack.....	182.98	34.18	36.95	3,631	12.12	1,253	3,252	417
29	Basic slag.....	180.87	31.45	37.61	3,736	12.75	1,315	3,714	861

Table II shows that in the 5-year cereal rotation at Wooster the corn and timothy have given slightly larger total yields on the plot receiving basic slag, while the other crops are larger on the ones receiving acid phosphate. The increase, however, is greater from the acid phosphate in every case.

*In all the experiments with fertilizers conducted by this Station every third plot is left continuously without either fertilizers or manure, and the increase is computed on the assumption that if the yield of Plots 1 and 4, unfertilized, were 30 and 33 bushels, respectively, the unaided yields of Plots 2 and 3 would probably have been 31 and 32 bushels.

At Strongsville all the crops except wheat show a larger total yield from the acid phosphate, and all except wheat and timothy show also a greater increase.

In the rotation at Wooster of potatoes, wheat and clover, the total yields of potatoes and wheat are greater after acid phosphate, and of clover after basic slag; the increase, however, is greater in every case after the slag.

The soils upon which the two cereal rotations are located are of low fertility and are quite uniform in character. The potato rotation, however, is located upon a comparatively fertile soil, the 15-year unfertilized yield of potatoes having been 160 bushels per acre, and that of wheat 26 1-2 bushels, whereas the yield of wheat in the cereal rotations has been but 10 1-2 bushels for the same period at Wooster and 7 bushels for the 12 years during which wheat has been grown at Strongsville.

As there is a limit to the normal size of every plant, so there is a limit to its acre yield, and the nearer this limit is approached the greater the difficulty in producing further increase. For example, it is far easier to raise the yield of wheat from 10 bushels per acre to 30 bushels, than to raise it from 30 to 40 bushels. In the potato rotation at Wooster the unfertilized yields with which the yield of Plot 11 is compared are considerably greater than those adjoining Plots 26, 27 and 29, and this may explain the relatively greater increase found on these plots by our method of computation.

In Table III is given the value for each rotation of the total yield and of the increase, as found by computing corn at 40 cents per bushel, oats at 30 cents, wheat at 80 cents, potatoes at 40 cents, stover at \$3.00 per ton, straw at \$2.00 and hay at \$8.00.

TABLE III:—VALUES OF TOTAL PRODUCE AND INCREASE FOR EACH ROTATION FROM DIFFERENT CARRIERS OF PHOSPHORUS

Station and carrier	Plot No	Value per acre for one rotation	
		Total	Increase
Wooster: Cereal rotation:			
Acid phosphate.....	11	\$ 91.34	\$38.94
Bonemeal	26	87.27	32.75
Dissolved boneblack	27	83.97	33.62
Basic slag	29	89.33	33.20
Strongsville: Cereal rotation:			
Acid phosphate.....	11	72.23	24.85
Bonemeal	26	70.07	24.11
Dissolved boneblack.....	27	66.11	21.17
Basic slag	29	68.75	25.03
Wooster: Potato rotation:			
Acid phosphate.....	11	122.21	19.60
Bonemeal	26	116.15	23.64
Dissolved boneblack.....	27	119.39	26.29
Basic slag.....	29	121.03	27.54

In the two cereal rotations the variations in the total and increase values are similar. In the potato rotation Plots 26, 27 and 29 show similar variations, indicating that the low increase found on Plot 11 is due to the cause above suggested.

The experiments at Wooster and Strongsville have been made on acid soils, and it is important to know whether like results would be obtained on soils of a different character. The experiment at Columbus is a partial answer to this question, but we have a little further light in the experiments on liming the soil which have been conducted on the cereal rotation at Wooster since 1900, when the plan was adopted of applying lime to one half of each of the five 30-plot sections included in the experiment, as it came under the corn crop, the lime being applied to fertilized and unfertilized plots alike. The crop of 1903 was so nearly a failure that the limed and unlimed halves were not harvested separately, but for the other four years of the period, 1900-1904, the yields have been as shown below:

TABLE IV:—YIELDS OF CORN FROM DIFFERENT CARRIERS OF PHOSPHORUS

Plot No	Carriers of phosphorus	Yield		Increase	
		Unlimed	Limed	Unlimed	Limed
		Bus	Bus	Bus	Bus
11	Acid phosphate.....	53.50	61.00	23.42	22.16
26	Bonemeal.....	53.14	60.91	20.56	20.29
27	Dissolved boneblack.....	54.64	61.09	21.84	21.15
29	Basic slag.....	52.66	58.36	19.64	19.10

It does not appear that the liming has materially affected the comparison, so far as the corn crops were concerned. The oats, wheat and timothy unfortunately were not separately harvested during the first few years of this test, except the oats crops of 1901 and 1905. The tables below give the results for the seasons when the yields were separated:

TABLE V:—YIELD OF OATS FROM DIFFERENT CARRIERS OF PHOSPHORUS.
AVERAGE OF 2 CROPS GROWN IN 1901 AND 1905

Plot No	Carriers of phosphorus	Yield		Increase	
		Unlimed	Limed	Unlimed	Limed
		Bus	Bus	Bus	Bus
11	Acid phosphate.....	59.92	58.51	30.21	17.92
26	Bonemeal.....	55.62	55.54	23.46	15.06
27	Dissolved boneblack.....	58.27	58.59	25.13	17.37
29	Basic slag.....	54.61	59.29	20.48	17.34

In the case of the oats crop the liming seems to have caused a relative increase in the effectiveness of the slag phosphate—just the opposite of what would be anticipated, if the additional lime carried by the slag is of material advantage on acid soils.

Table VI gives the average yields of the five crops of clover hay—1900 to 1904 inclusive—following the liming:

TABLE VI:—YIELDS OF CLOVER FROM DIFFERENT CARRIERS OF PHOSPHORUS

Plot No	Carriers of phosphorus	Yield		Increase	
		Unlimed	Limed	Unlimed	Limed
		Tons	Tons	Tons	Tons
11	Acid phosphate.....	1.43	1.92	0.70	0.79
26	Bonemeal	1.51	2.08	0.76	0.96
27	Dissolved boneblack.....	1.19	1.96	0.43	0.74
29	Basic slag.....	1.44	1.75	0.65	0.59

The clover crop shows practically the same yield but a smaller increase after the slag than after the acid phosphate on the unlimed land, and a smaller yield and increase on the limed land. As stated further on, however, the hay weights do not show the full effect of the different carriers on the clover.

The acid phosphate used in this trial has been the commercial grade, sold to contain 14 percent available phosphoric acid as the minimum. The basic slag has been sold to contain 17 percent and over of total phosphoric acid. The acid phosphate has been used at the rate of 320 pounds for each rotation—80 pounds on corn, 80 pounds on oats and 160 pounds on wheat. The basic slag has been used at the rate of 260 pounds for each rotation, 65 pounds each on corn and oats and 130 pounds on wheat, thus giving a total of 44.8 pounds of phosphoric acid in the acid phosphate and 44.2 pounds in the slag, on the basis of the claimed composition.

Associated with the phosphates has been a total of 480 pounds of nitrate of soda—160 pounds on each crop—and 260 pounds of muriate of potash—80 pounds each on corn and oats and 100 pounds on wheat. The fertilizer would therefore have an average percentage composition of about 8 1-2 percent “ammonia,” 4 1-5 percent “phosphoric acid” and 12 percent “potash,” thus giving such a surplus of nitrogen and potassium that there could be no possibility of the action of the phosphates being limited by lack of these elements. That no such limitation occurred is shown by the outcome on Plot 17 in these tests, a plot which has received, for each rotation, 240 pounds of nitrate of soda, or one half the quantity given to Plot 11 and the other plots in the phosphate

comparison, with 480 pounds of acid phosphate, or 50 percent more than that given the other plots, and the same quantity of muriate of potash. The yields of Plots 11 and 17 are compared in Table VII:

TABLE VII:—COMPARISON OF PLOTS 11 AND 17: YIELDS PER ACRE

Crop	Unlimed		Limed	
	Plot 11	Plot 17	Plot 11	Plot 17
Corn, bushels.....	53.50	48.98	61.00	63.48
Oats, "	59.92	58.90	58.51	61.32
Clover hay, tons	1.43	1.14	1.92	2.07

On the unlimed land Plot 17, with its smaller allowance of nitrogen, gives a smaller yield than Plot 11; but when lime is added nitrification in the soil is accelerated and Plot 17, with its larger supply of phosphorus, passes Plot 11 in yield of all the crops except wheat.

The dissolved boneblack used in this test was purchased in ready-mixed form at the outset, but later on it became difficult to secure it in this form and it was mixed for the purpose from bone charcoal and sulphuric acid. It is possible that we did not secure as perfect a combination of the two materials as is done when they are mixed in larger quantities and allowed to stand for a considerable time before use, and therefore the sulphuric acid may have been liberated in the soil more readily, thus tending to increase the soil acidity to a greater extent than the acid phosphate. It is true that the clover weights, as given in the table, show but little difference between these two carriers; but as seen in the field it has been evident that Plot 27 carried much less clover than either of the other three, and that a larger part of the weight harvested from it consisted of weeds. Throughout the later years of the test the superior growth of clover on Plots 26 and 29 has been very conspicuous, as compared with Plot 27; but Plot 11 has fallen but little behind in this respect.

Up to 1905 the bonemeal used in this test was raw bonemeal, being used at the rate of 220 pounds for each rotation; but in the spring of that year and since steamed bonemeal has been used, at the rate of 180 pounds per acre, a comparison at Strongsville of the two bonemeals having indicated that the steamed meal is the more effective carrier of phosphorus.

The basic slag used in the earlier and latest experiments was of German manufacture. In 1906 a slag of American manufacture was substituted. Our analyses of the German slag indicated an average of barely 17 percent total phosphoric acid. The American slag showed 19 percent. As this material is no longer manufactured in America we have been compelled to return to the German slag in order to continue the experiment.

CONCLUSIONS.

The outcome of the 20 years' work summarized in the preceding pages seems clearly to indicate that acid phosphate has been the most effective of the four carriers of phosphorus employed in these experiments for the cereal crops, while bonemeal and basic slag were preferable for clover on acid soils. When, however, the matter is considered from the standpoint of a complete rotation, embracing both cereal crops and clover, it appears that on these acid soils the utmost that can be claimed for basic slag is that its total phosphorus has been of equal effect with the available phosphorus in acid phosphate, or the phosphorus in fine bonemeal, pound for pound, and that no additional value can be ascribed to the basic slag because of the lime or other substances which it may have contained; while on soils that have been limed the pound of total phosphorus in basic slag has been less effective than the pound of available phosphorus in acid phosphate or in fine bonemeal.

It will be observed that in all these experiments the various phosphate carriers have been used in conjunction with nitrate of soda, but other experiments have shown that on acid soils nitrate of soda is a more effective carrier of nitrogen than the organic carriers (animal refuse, oilmeals, etc.) usually employed in the compounding of commercial fertilizers. In the absence of nitrate of soda, therefore, it is possible that basic slag would be relatively more effective on acid soils than it has appeared to be in the experiments above reported.

Since, however, nitrogen may be purchased in nitrate of soda more cheaply than in the average ready-mixed fertilizers this point is of little practical importance.

While these experiments would indicate that it would be possible to correct soil acidity by the use of basic slag, yet this would be an expensive method, for a ton of quicklime should neutralize as much acidity as three tons of basic slag, and over most of Ohio the cost of a ton of quicklime will not exceed one-third that of a ton of basic slag.

There is reason to believe that acid phosphate increases the tendency to soil acidity, but it is not the sole cause of such acidity, for there are very acid soils which have never received any acid phosphate. On such soils it is necessary to correct the acidity before they will yield a full harvest, and lime is the cheapest material for this purpose; but the additional amount of lime required to neutralize the sulphuric acid in an ordinary dressing of acid phosphate is a very small quantity.

H. S. Grindley.

OHIO AGRICULTURAL EXPERIMENT
STATION

*Report of the Division of
Horticultural Inspection*



CONTENTS.

Preface.....	Page 1
Introductory.....	4
Sectional uniformity in orchard practice.....	6
A striking example of orchard renewal.....	11
Horticulture in the Maumee valley.....	13
Efforts to control pear blight in northern Ohio.....	16
The home of the grass-mulch method of orchard culture in Ohio.....	18
A promising orchard in south-central Ohio.....	23
Horticultural achievements in southern Ohio.....	27
Fruit production for the retail market.....	34
Protection of fruit trees from rodents.....	38
The old and neglected orchard.....	39
Hill-top gardening.....	42
Potato growing in the Huron valley	44
A potato growers' meeting in the Sandusky valley	49
A typical orchard problem.....	51
Two new seedling apples of merit.....	54
Two new seedling plums.....	57
Three new seedling strawberries	58
A subject of modern interest.....	62
A new type of Concord grape.....	63
Two illustrations of bud sporting in apples.....	66
A striking lesson in plant selection.. ..	68

Ohio Agricultural Experiment Station.

CIRCULAR NO. 94.

WOOSTER, OHIO, APRIL 29, 1909.

REPORT OF HORTICULTURAL INSPECTION.

BY F. H. BALLOU.

PREFACE.

The Division of Inspection of the Horticultural Department of the Ohio Agricultural Experiment Station was created late in the spring of the year 1908, when the fund which, for two years previous, had been appropriated to the State Board of Agriculture, at Columbus, for the joint support of a Division of Horticulture in that institution and the Ohio State Horticultural Society was, very unexpectedly, to all concerned, transferred to the Horticultural Department of the Experiment Station. While the purpose of this transferred fund was not clearly defined by the Senate Finance Committee which was responsible for the change, it was quite naturally assumed by all who were familiar with the former arrangement that the fund was yet designed for the support, at least in part, of the Ohio Horticultural Society. In accordance with this supposition the Executive Committee of the Horticultural Society proceeded to elect its Secretary. The choice was fixed upon one who was already an attache of the Horticultural Department of the Station, in the capacity of Assistant Horticulturist, and who by special arrangement was devoting one-half of his time to work for the Station. However, the Assistant Auditor of State ruled that, as no reference to the State Horticultural Society had been made by the Senate Finance Committee in its transfer of the appropriation from the

State Board of Agriculture to the Experiment Station, no part of that fund could be legally used in support of the Society. In this dilemma the Station came to the rescue of the Society by privileging the Secretary elect, in addition to his regular line of duty as assistant horticulturist plus the added work as assistant in charge of the new Division of Horticultural Inspection, now requiring all his time, to perform the service involved in editing the Society's transactions and otherwise caring for its affairs; but this service was to be no part of his duty to the Station nor included in the service for which his salary was paid. It was, therefore, evident that the wording of the appropriation measure, which provided simply for Horticulture and Horticultural Inspection, should be followed by the Station in letter as well as in spirit—that inspection and study of horticultural conditions, possibilities and requirements, in different parts of Ohio, should be carried forward primarily for the purpose of analyzing such conditions, calling attention to such possibilities and endeavoring to devise ways and means to meet such requirements as might be discovered.

This new line of work, because of the lateness of the date at which the appropriation was made, and because of a general uncertainty of the real purpose for which the sum was set apart, was not regularly taken up until late in the summer of 1908. The specific lines taken up at this discouragingly late date were: Observations of the special adaptation of various sections of Ohio to the growing of certain products; the possibility of successfully growing these same products upon a scale sufficient for home consumption and local markets in the lesser horticultural areas widely distributed throughout the state; the methods employed in the leading horticultural sections and a study of how far these methods might be employed to advantage in the less important, small or isolated areas; the examination of new fruits and other horticultural products originating in various parts of the state, or of improved strains of standard varieties springing into existence through plant breeding, or accidental, plant variation, and the holding of one or more field meetings where the horticultural public might be brought within close, personal touch and observation of striking horticultural object lessons.

The results of the season of 1908, to date, obtained in part from travel and observation, though principally through communication by correspondence with Ohio citizens in every walk in life, suggest that, in the main, no mistake was made in affording means for at least a temporary study of the horticultural interests and needs of our people. In view of the great field for usefulness and helpfulness

which such investigation, together with former observations along the same lines, has opened and spread before us, we may only trust that the way may be still more widely opened and more clearly defined for meeting the demands which are insistent upon every hand. These demands, as we shall see, are unmistakable in their character and significance; their recognition is the real, the true and the most important result of the work of the Division of Horticultural Inspection, and they suggest immediate preparation for enlargement of scope which should, by all means, transpose the Division into one of *Horticultural Extension*. A further simple seeking for peculiar conditions and requirements, alone, in horticulture, could hardly be justified when these are clearly apparent upon every hand and when our every mail embraces inquiries and requests which should indicate and direct, in a great measure, our future course. This course should involve no greater outlay of money than a simple system or plan of inspection. It should include, in brief, the preparation of such clearly written and attractively illustrated, elementary publications as will fully and faithfully cover "the great interrogation point" with which those, to whom the first principles of horticulture are strange, so persistently approach the Horticultural Department of our Station.

Such a change in the character of the work of the new Division is most respectfully suggested and earnestly submitted for the consideration of those who shall be responsible for the continuation and enlargement of the work.

It is earnestly hoped that all, into whose hands this report may chance to fall, may go with us in our brief observations of the wonderful, peculiar and varied characteristics of our great State; of the progress and achievements and ambitions of our representative and foremost horticulturists; of the remarkable horticultural awakening of the multitude which is pressing countryward, whose insistent appeal to institutions of horticultural and agricultural education, experiment and research, for help along elementary and practical lines, should by no means be ignored nor overlooked.

INTRODUCTORY.

Truly Ohio is a rare garden spot wherein widely varied conditions, degrees and conditions of soils, elevation and climate combine to produce the widest possible range of choice products of the north temperate zone. Were the inhabitants of the state limited to the food products grown within its borders, we should yet be a substantially and luxuriously fed people. Were the materials for the construction and adornment of our homes confined to the product of Ohio woodland, coppice and border, such homes might yet be surrounded by trees, plants, shrubs and flowers which would leave little to be desired from the flora of neighboring states or foreign lands.

Hundreds of square miles of cereals blanket our western Ohio plains and valleys; fruitful, well-kept peach orchards have taken possession of the peninsula of eastern Ottawa county and other choice locations in northern Ohio; model vineyards border Lake Erie and cover extensive areas of the islands adjacent to the Ohio shore; apple orchards of noted repute for fruit of exceedingly brilliant color and superb quality are clothing the rugged hills of southern Ohio; broad fields of celery and onions annually abound in the fertile, reclaimed marsh-lands of Hardin, Medina, Wayne and other counties; great areas of potatoes extend throughout the basins of the Cuyahoga, Huron, Mahoning, Muskingum, Miami, Maumee, Sandusky and Scioto rivers and their tributaries as well as over the clays, loams and silts of the uplands adjacent to the headwaters of the Rocky, Killbuck and Tuscarawas.

These great districts of especial adaptability to the production of certain crops constitute one of the features which lend to Ohio a measure of independence equalled, perhaps, by few other individual states and excelled by none. But this is not all—the best yet remains to be told; it is this: There is scarcely a farm or a home lot in the state, no matter how small, isolated, hilly or rough, but where there are certain favorable little nooks or slopes or elevations or protected, fertile depressions, where all of the horticultural products enumerated can be grown in generous supply and of the most excellent quality, for family use or for the many brisk and appreciative home markets which abound within reach of almost every section.

There are but few property owners, indeed, in Ohio, who do not possess some peculiar advantage contributing to home-making or the growing of certain products of the soil. The growers of garden

products for the city markets, as a rule, locate near their markets and usually where the ground is level. Their special advantage is the comparative ease and cheapness with which such land may be tilled and cultivated. The land-owner back in the hills is sometimes almost covetous of these conditions; yet when seasons of late frosts in spring or early frosts in autumn cut down the crops of the valley gardener, he who possesses the greater elevation, even though handling of the soil be much more difficult, discovers reasons for self-congratulation and realizes, after all, that He who is responsible for the topographical shaping of our land has builded better than we should have done; that He is not a respecter of persons and has granted to all special, peculiar opportunities and blessings.

As these lines are being written, on the 21st day of October, 1908, all tender plants in the vicinity of the writer's home and office, in the valley of the Licking river, with an elevation of near 800 feet above sea level, have been sear and brown for many days, as the result of early frosts. At a small fruit farm eight miles distant lying between, and upon protecting hills and at an elevation from 1000 to 1200 feet, the tomato vines are green and yet maturing some fruit that is fairly good for table use; the foliage of fruit trees is green, bright and fresh, and conditions and appearances in general are sufficient to warrant the thought "verily this is a different and a milder climate."

With the extension and multiplication of facilities for rapid transit to and from country districts, there has come a general exodus of professional and business men, with their families, from the city. Even as they drifted, in their early manhood, to the villages, towns and cities, lured by the apparent promise of greater opportunities therein, so are they now drifting back to Nature where country homes may be established and their hours of respite from business or professional cares may be spent amid surroundings congenial to the great and rapidly increasing host of nature lovers and nature students of our day. These hundreds of newly awakened home-makers—fathers and mothers, sons and daughters, all equally enthusiastic—are clamoring for simple instructions in the first or rudimental principles of horticulture, forestry, floriculture and home adornment. They are determined to succeed in their new gardening, fruit-growing or farming operations, yet they realize their lack of that practical knowledge and training which would insure success. It is with no humiliation that they seek information; it is with the same energy and determination which have characterized their business and professional methods that they

communicate with or visit our educational and investigational institutions. They eagerly ask for help and confidently expect it to be forthcoming. The advanced technical and scientific publications commonly in the majority and available in unstinted supply do not especially appeal to them; those phases may become subjects of interest later on. They are especially looking for short, crisp, beautifully and truly illustrated treatises which will enable them to prepare for, select, plant, protect, propagate, prune, train, spray and attain, in a reasonable degree of perfection, the fruits of their thought and labor. An insistent demand in a worthy cause remains not long unsatisfied. The time is near at hand when experiment stations and agricultural colleges in general shall fully recognize this want and will promptly come forward with that which shall meet it.

SECTIONAL UNIFORMITY IN ORCHARD PRACTICE.

PEACH CULTURE IN OTTAWA COUNTY.

It is quite safe to assume that the history of orchard practice, in the different extensive horticultural centers of our country, is essentially similar. The years required for the establishment and development of the industry witness methods of planting and care almost as many and varied as the number and characters of the orchardists who inaugurate these unlike methods. As the industry grows in years, the methods of those who succeed best attract the attention of wide-awake and observing neighbors who promptly adopt the favorably noted improvements, modifications or distinctly different plans or systems, as the case may be. It was stated to the writer, by a leading orchardist of northern Ohio, that the ultra-progressive fruit growers in his section observe their neighbors' operations with hawk-like concentration and are quick and sure to seize upon a plan or practice that is proving superior to their own; and that only the lazy and shiftless growers are lagging in the grooves worn by former generations.

This general adoption of the more excellent practices prevailing in a particular fruit growing section results, naturally, in a method which is, in a measure, peculiar to that section. A certain local standard is thus gradually evolved and established, which is thereafter difficult of further modification because of a prevailing disposition on the part of the growers to withhold recognition of

merit in any plan or scheme in practice which does not essentially conform to these well-fixed, sectional ideas. In illustration, we are familiar with the attitude of those who believe only in annual tillage and persistent, clean culture of orchards, toward the plan of planting and growing trees in sod land, with heavy mulching. We have experienced the futility of describing the Kniffen or "drooping system" of grape training to a company or audience of veteran vineyardists who have, for a quarter or half-century practiced the old, upright renewal or "fan-system" of training. I was told this season of a German gentleman who is a staunch adherent to the "old school" of grape training, visiting the garden of a young neighbor who is taking much interest in the more modern systems of grape culture. The veteran critically eyed the long-stemmed vines stretching up to the point from which the bearing laterals should later droop. Reaching into his pocket he whipped out a formidable pruning knife and quickly cut off several of the vines only a short distance above the ground, with the remark: "dot vhas more like id." We are aware of the hesitation of those who have ever favored tall-bodied, high-branched orchard trees and the "pruning up" of orchards generally, to believe that there can possibly be saneness, to say nothing of safety and merit or common sense, in planting short-stemmed trees and severely and persistently "heading down" to facilitate all orchard operations. Yet we are aware that the various methods in different sections are bringing success to those who faithfully follow the plans of their choice.

In that part of the lake-shore peach belt embracing the great peninsula of eastern Ottawa county, north of Sandusky Bay, we have a good example of sectional uniformity in methods of orcharding. Of course there are slight variations, though these are just sufficient to leave the stamp of personality upon the plantations of various individual orchardists. Outside of parts of Catawba and other islands in proximity to the Ohio shore and the coast vineyards of Lake, Cuyahoga and other counties, it is doubtful if there can be found in Ohio another section where horticultural practice appears to be so nearly uniform.

It was the privilege of the writer, in August, 1908, in company with a number of central and southern Ohio fruit growers, to enter via the Lake Shore & Michigan Southern Railroad, the peach section in the vicinity of Gypsum and Port Clinton, on the peninsula. Here meet the eye, upon every hand, great areas of peach trees—the straight rows extending in some cases almost as far as the eye can reach. The trees, even of old orchards, are short-stemmed, broad-topped, low-down, sturdy, compact and the picture of health and

vigor. Apparently there is not a single foot of unnecessary leverage which can be exerted upon the branches by the burden of fruit, the danger of breaking and mutilation being reduced to the minimum by this method of pruning, together with systematic thinning of fruits when the crop is heavy.



Fig. 2. Peach orchard near Gypsum, Ohio.

Short stemmed, broad topped, sturdy and compact.

It was a revelation to the fruit men of the more southern sections of the state. Remarks of surprise, wonder, admiration and commendation were heard upon every side; note-books appeared from pockets and pencils traced lines which recorded items of unusual novelty and interest to be dwelt upon at a later time in the quietness of their own homes. Here were great, cleanly cultivated orchards, whose trees might receive their annual pruning from a six foot step ladder; whose tops were subject to the peculiar covering power and merciless penetration of a downward directed spray from the elevation of an ordinary spray wagon; whose fruits might be readily, for the most part, gathered from the ground or from short step-ladders.

There is probably not another section in the state where the systematic pruning of orchards has been accorded such thought and attention, or reached so high a degree of perfection as in the peach belt of northern Ohio. The occasional apple orchards, too, are claiming their share of attention in this respect. This advanced progress in the science of pruning is due to a number of factors, possibly the most potent of which was the scourge of San Jose scale which infested this district a number of years ago. This enemy

obtained so strong a foothold before it was successfully combatted that cutting back the trees to mere "stubs" was rendered necessary, in order that every part should be fully covered by the lime-sulphur wash. In spite of this actual mutilation those orchards which were not yet devitalized by the scale promptly threw out healthy shoots which were annually and severely "headed-in" to preserve the much reduced altitude of the tree-tops. The practice of low heading and severe annual restriction therefore became a prevailing method, not alone because of the greater facility with which the trees could be treated, but because of a growing appreciation by the orchardists of a method embodying a definite system, extreme neatness and highly satisfactory results in the character of the product obtained thereby.



Fig. 3. Peach orchard east of Gypsum, Ohio.

An example of perfect cultivation
and close pruning.

Three additional factors render the northern Ohio peach belt superior to more southern locations: climate, topography and comparative freedom from the dread disease of "yellows." The warmth stored up in the vast body of water of Lake Erie, during the hotter months of late summer and early autumn, so modifies the temperature of the atmosphere that development and maturity of the wood growth and the fruit buds of the trees are seldom interfered with by premature freezing weather. The cold currents of air from the north which, in autumn, in more southern parts of our state, most

surely indicate the coming of frost, only bring, to the lake shore belt, on their undercurrents skimming the warm surface of the water, a temperature so modified as to eliminate grave danger of too early frost. Likewise, during the winter months, the great body of water becomes so icy that the temperature of the lake region is held at a low degree until late in spring, retarding premature expansion of fruit buds until danger of late freezing has passed.

The almost perfectly level surface of the land in central Ottawa county, and the northern part of the state generally, renders possible annual tillage of orchards. This cannot be done safely in the central and southern parts of the state where the land is hilly.

Annual plowing and clean cultivation, season after season, was the former plan of culture in the northern peach country; but the time arrived when, by this policy, the vegetable constituent of the soil reached so low an ebb that hundreds of acres of orchards suffered most severely. This, together with the effects of scale, leaf-curl and exhausted fertility, was responsible, in a great measure, for the death of whole orchard plantations during the severe winter of 1903-4. Growers of this section now recognize the importance of keeping up the supply of humus in the soil—either by the application of stable manure, where it is available, or by the annual growing and turning under of leguminous or other plants.

While some loss has been sustained through “yellows” the orchards of the north are singularly immune, as compared with the central and southern portions of Ohio, where this disease has reached the proportions of a dreaded scourge.

Now, what are the conclusions to be drawn from this chapter? These are those which, from equally close observation in other parts of the state, today confront us:

- 1 The great bulk of Ohio's home grown peaches must, under conditions similar to the present, be produced within the northern quarter of the state.

- 2 Lesser quantities will be continued to be grown in small, widely separated, especially favored spots in Ohio. In these isolated sections there is need of employing the better methods in vogue in the northern regions of the state, with certain modifications to suit local requirements.

- 3 There will hardly come a time when peaches will not be planted, at least in a small way, in connection with nearly every Ohio home, by lovers of this luscious fruit.

4 Inasmuch as a great number of our people will ever be interested in the growing of peaches, to a greater or less extent, it is incumbent upon those whose duty it is to extend worthy and helpful horticultural information, to disseminate such practical knowledge, in the form of literature, as shall bear clearly, forcibly and attractively upon the subject.

5 Among the elementary publications touching general orchard practice, none is in greater demand at the present than something dealing very briefly and clearly with pruning. Methods of culture must necessarily be modified to a considerable extent according to local physical characteristics of the section; but pruning and, I may well add, budding and grafting, are subjects of universal interest and application.

A STRIKING EXAMPLE OF ORCHARD RENEWAL.

There have been few bulletins issued in late years from the Horticultural Department of our Experiment Station, which have met with a kindlier reception or a wider demand, than "No. 180," which contained a brief, preliminary report upon a little experiment conducted in the Station's orchard, in renewal or rejuvenation of old apple trees. The writer alone has received some 400 letters inquiring about, requesting or commenting upon this bulletin. These letters came from every part of the United States—from Maine to California and from Wisconsin and Minnesota to northern Florida and Louisiana. These numerous letters afforded interesting data relating to actual conditions of old orchards in different parts of our country, but evidenced, as well, the awakening interest in these old and too long neglected institutions, many of which were established simultaneously with pioneer homes. Many of these letters came from persons who have, within recent years, come into possession of properties upon which these old orchards are situated. A considerable percentage of such transfers were made to buyers from cities, who evidently were seeking country homes. No doubt the old orchards may have played some part in the closing of many contracts—we do not know except in a few cases where statements to this effect were casually submitted; but it is clear that in every part of our country such orchards are, after all, farm and home problems of no little moment. Even under the most promising circumstances the renewal of old orchards is not all poetry and sentiment. Such work is attended by a deal of hard, wearing labor; and while results, where conditions are favorable, will repay well the expense of so doing, the old orchard should by no means be expected to take the place of a younger one, but to fruitfully and

profitably stand between the time of planting and the age of generous fruit bearing, of the newer generation.

At the time of taking up the subject of orchard renewal, at the Ohio Station, the writer, who was in immediate charge of that character of work, was not aware that operations of a similar nature were in progress in the state. This, however, was the case; and it was with real pleasure that it was discovered, during the summer of 1908, that an orchardist of Port Clinton, Ottawa county, had quietly inaugurated just such an experiment in 1901-2, as did the Station three years later. This pleasure, it is frankly confessed, is not so much because we find that the Station was anticipated three years in this work, by our Ottawa county friend, as because of the fact that his sentiments, his methods and his results, maturer than our own, are so closely in accord with those published in Bulletin No. 180, of this Station.

In July, 1908, a call was made at this fruit farm and the work which he has accomplished looked over with much interest and satisfaction. The observations herewith recorded as a result of such inspection certainly should be accepted as most excellent support of the statements contained and the instructions given in Bulletin 180.

The apple orchard was planted by the present owner in 1871. Before it came into bearing, however, he became engaged in business which required his presence elsewhere. For twenty-five years he remained away, finally returning in 1900. In the interim the orchard, which was growing upon excellent soil, had been pruned only to such an extent as to stimulate heavy, upright growths. From twenty foot ladders it was impossible to gather the fruit from some of the lateral branches. Spraying was especially difficult; and as San Jose scale was infesting his orchard, spraying in the most thorough manner became absolutely necessary.

The owner was also confident that, by lessening the height of the tops of his trees, he would reduce the number of "windfalls," secure increased size and better quality of fruit because of less bearing surface, and not least of all, improve the appearance of his orchard to a considerable degree.

The work of renewal was not done in a single season—the task was too great; but it was vigorously begun the spring following his return to the farm, and finished in 1902, so far as the heavy cutting was concerned. Many main branches extended well above the mean elevation to which he wished to reduce his trees, and some of these were from four to six inches in diameter at the point of cutting.

The new growths following the vigorous cutting were faithfully thinned and pruned back annually. In short, the work of heading back and the after treatment has been substantially the same as that recommended in Bulletin No. 180 to which the reader is referred for details.

The accompanying photograph shows a distant view of the renewed orchard with the owner in the foreground as a standard for comparison as to height. He has pointedly expressed his personal attitude and that of his two loyal sons, toward renewal of old orchards, in this sentence: "While the boys and I take lower views of our apple trees, we take higher views of life. We do not recommend that apple trees be planted and allowed to "sow their wild oats" before taking them in hand. Better would they be led in the way they should go, then, when they are old, they will not depart from it."



FIG. 4. An example of orchard renewal near Port Clinton, Ohio.

HORTICULTURE IN THE MAUMEE VALLEY.

The western limit of the great Lake Erie fruit belt, in Ohio, may be said to be that part of the state within the radius of 25 or 30 miles west and south of Toledo. This portion of the state is very level except in proximity to the larger streams, where the cutting down of the channels in past ages has caused slight erosion of the bordering land. The low knolls and slight slopes (called "hills" in that section) are most excellent sites for orchards—especially for the peach. The lake is not so far distant but that climatic conditions are measurably influenced by it, affording opportunity for wood growth to mature in autumn and retarding the opening of fruit buds in the spring. South and west of this not definitely defined limit the country merges gradually into the great agricultural section of western and northwestern Ohio, wherein fruit growing is engaged in only in small and widely separated areas.

The valley of the Maumee river, south from Toledo, is not only celebrated for the tragic events in the early history of Ohio—when the waters of the Maumee “ran bloody from battle,” but is, in our day, noted for its fertility and the abundance and excellence of its agricultural and horticultural products.

A number of land owners of the valley make a specialty of fruit growing. Beginning with small fruits, the season is extended through the time of maturity of all classes of tree fruits and continued throughout the winter by means of spacious, private cold storage in which great quantities of winter apples are carried until such time as prices warrant placing them upon the market. “Marketing by trolley” is one of the novel features of this wonderfully productive valley. Whereas, in former days all produce had to be hauled from 20 to 30 miles by wagon, each load requiring a long days jaunt, the fruits are now loaded upon the electric express cars at a nearby village and, in from one to two hours time, are delivered, fresh and attractive, at the wholesale or retail establishments in Toledo.

One of the principal objects in visiting the Maumee valley fruit section was to observe methods of orchard pruning as compared with other sections in northern Ohio. It was found that here, aside from removing dead branches and thinning out those which crowd or interfere with each other, little cutting is done. Apparently large, broad-headed trees are desired—such as will carry the maximum quantity of fruit. Good size of individual specimens is obtained by systematic thinning of the fruit on the trees, rather than by restriction of tree growth. Peach trees are, of course, annually pruned back, though not to the extent that is done in the Ottawa county district.

A few orchards present valuable lessons in economic cultivation—in obtaining the greatest possible returns from the ground occupied by the trees while the young trees are growing. Bush fruits—principally currants—are planted between the rows and come into bearing in one or two seasons from the time of setting. These are permitted to fruit until the orchard comes into bearing and as long afterward as both crops do well. Potatoes are also grown between the rows of young trees. Potatoes and asparagus are largely grown. A plantation of ten acres of asparagus was noted growing on first bottom land bordering the Maumee river.

The success of those land owners first engaging in horticulture in the valley, early attracted the attention of certain neighboring farmers who also began planting orchards to some extent. The advent of the San Jose scale, however, frightened the majority of

these planters, who were soon ready to abandon their new undertaking. This resulted in the more confident growers leasing a number of orchards which were the more promising, thus adding materially to their already extensive acreage. These farming and horticultural operations require a small army of laborers to accomplish the work in field and orchard; but everything goes forward with smoothness and in a systematic manner.

Nowhere in the state is there more heed given to the requirements of the soil in heavy crop production. Both cultivation with cover crops and mulching and a combination of these methods are practiced with success. There is no partisanlike adherence to any certain or set plan of orchard management. A method which will conserve and improve the productive capacity of the ground is looked upon with favor. Good culture by one or more of these means, thorough spraying and systematic and courageous thinning of fruits, is the slogan in the valley of the Maumee.

The great business carried on by these representative Ohio horticulturists; their personal familiarity with conditions existing in various sections of our own and other states, from extensive travel and mingling with soil culturists in institutes, conventions and societies; their liberal mindedness in recognizing the obstacles to be overcome by culturists who work under very different environments, have so broadened their views of horticultural requirements in the different parts of Ohio as to render them in sympathy with all classes of growers who labor under these diverse conditions. Thus have they come into possession of those qualities which combine to produce true, earnest, helpful horticultural teachers. A substantial increase in the number of such men in our own and other commonwealths would rebound to the steady advancement of horticultural interests and practices everywhere.

It is interesting to note that, in the northwestern portion of Ohio, represented by Lucas and Wood counties, we find topographical, physical and climatic features very different—almost opposed to those observed in the central, eastern and southern areas of the state. Each section, however, possesses certain attributes which render it a worthy competitor of the other, in fruit production; and, as well, each has its drawbacks which make it incumbent upon the horticulturist to study local as well as general requirements in orchard and garden practice.

It has been the privilege of the writer to accompany the orchardist of the Lake Erie belt to the steep, rugged, orchard-covered, sunny hill-slopes of southern Ohio; likewise to accompany the orchardist of the rough, Ohio river section, to the floor-like levels

of the northern Ohio fruit districts. The first shudders with fear and expresses misgivings as to personal security as he rides through rocky, rough ravines and over dangerously steep and gullied hillsides and compares these features with his level ground and straight rows at home. The second studies with wonder and admiration the novel features of orcharding in the north, but soon tires of the monotonous levels and hails with exclamations of relief and delight the sight of the hills as he is hurled homeward on his south-bound train.

EFFORTS TO CONTROL PEAR BLIGHT IN NORTHERN OHIO.

After a period of discouraging experiences with pear blight, during which thousands of valuable trees withered and died and other thousands were more or less mutilated in cutting away the terrible disease, growers of this excellent and desirable fruit, in northern Ohio, are meeting with a degree of success that inspires a bit of old-time confidence in planting anew as well as endeavoring to renovate and restore the old.

As mentioned in another chapter of this report, the erstwhile general orchard practice, in this northern section, was annual plowing and clean cultivation. When the scourge of blight fell upon the orchards the devastation wrought was apparently severe in proportion to the excellence of culture and fertility of the soil. This introduced a lesson in horticulture that was novel in the extreme. The less careful grower—the one in whose orchards a sprinkling of weeds or grass was not infrequently found, or the one who, through necessity, or otherwise, allowed the practice of annual plowing to “skip a cog” now and then—suffered less from blight than his more scrupulous neighbor. Here, indeed, was a lesson worth noting; and it was one that the wide-awake grower pounced upon. This was not without some misgivings however. It required courage of a special quality to ignore the traditional earmarks of the careful husbandman. The discontinuance of cultivation, the sowing of the orchard area to grass; the development of a true sod; the substitution of the mowing machine and the scythe for the cultivator, harrow and hoe were likely to be branded as evidence of fanaticism if not of insanity.

Prominent among the first to break away from old methods was a studious orchardist of Ottawa county. He had suffered severe loss through blight. His orchards were rapidly trending toward destruction. At this critical time he sowed a part of his orchard to

grass. A check in the growth of the trees was noticeable the following season and a corresponding check in the progress of the disease was noted. Cultivation on the other part of the orchard was later discontinued with like results. Today there is still to be seen a remarkable difference between the two plots, in favor of the one in which cultivation was first abandoned. Cutting out the dead and diseased branches had been done, though at first without close regard to details.

With the advent of San José scale the lime-sulphur treatment of orchards was introduced. This, together with persistent cutting out of blighted twigs and branches availed still further in control of the scourge. Partial success stimulated a more careful study of the definite history of the bacterial disease. Many cankers which were existing as sources of infection, and which had been responsible for continued outbreaks, were discovered and cut off or pared down and treated with fungicides. The trouble still further diminished. Planting of young trees was resumed and these, for the most part, lived and are now growing and approaching the fruitfulness.

In all this discouraging experience, this orchardist did not seriously contemplate the substitution of varieties of greater resistance to blight. Had he done so, his alternative should have been to plant Duchess, Seckel or Keiffer as these are representative of the resistant class. The Duchess is not a profitable bearer as a standard tree; the Seckel is too small; the Keiffer is too poor in quality. His favorite variety was and is the Bartlett. Bartlett he would grow were such a thing possible. Inasmuch as Duchess had survived the blight and seemed resistant to a high degree this "tip" from nature suggested using this variety as a stock upon which to top-work Bartlett, thereby eliminating at least the graver danger of body blight or canker. A considerable block of Duchess was planted and has been successfully top-budded to Bartlett. This young orchard, at the time of the writer's visit in July, was the picture of health and vigor, and will, in another year or two, be bearing freely.

This grower, while achieving a measure of success is not exhibiting over-confidence in blight control. He only states that it is his belief that he is making progress and he hopes in the near future to be able to control the disease as are other troubles of the fruit grower, which, a few years ago, seemed beyond control.

At the time of the writer's call at this place, there was a trusted man in the pear orchard cutting out blighted twigs and branches and seeking for and summarily dealing with more or less obscure

sources of infection. The tools were sterilized, after each treatment, by being dipped into a weak solution of corrosive sublimate.

From the crop of smooth pears in sight, there was abundant evidence that the thorough lime-sulphur sprayings; the persistent removal with sterilized tools, of all diseased parts; the subsequent summer sprayings with copper compounds for scab of foliage and fruit and, with all, the eagle-eyed vigilance in seeking out and eliminating first evidence of the trouble, is enabling this orchardist to secure the merited reward.

THE HOME OF THE GRASS-MULCH METHOD OF ORCHARD CULTURE IN OHIO.

While not generally spoken of as a special horticultural section of Ohio, the table land bordering the valley of the Olentangy or "Whetstone" river in southern Marion through Delaware and in northern Franklin counties, exhibits possibilities in fruit production second to none in the state. As a nucleus about which the lesser horticultural enterprises are scattered, and representative of what might be accomplished in central Ohio, is an excellent apple orchard near Delaware, which has the distinction of being the home of the *grass-mulch method* of orchard culture in Ohio.

The life history of a great-hearted man, of a farm and of a system of orchard management which has become widely known by professional horticulturists in this and other states, is intensely interesting; and it is a matter of regret that this history, in full, cannot be given in this report. It can only be stated here that this farm was hewn from the virgin forest; that in that work the present owner, then a boy, actively assisted his father, driving the teams of oxen during the several seasons of heavy, wearing labor in "logging off" the ground; that, later on, the place became one of the foremost Short-horn cattle farms in Delaware county; that pasture fields of blue grass took the place of the forest; that for forty years some of these pasture areas, in which the plow was never introduced, were storing up plant food and developing into veritable gold mines for the future use in which they should be utilized; that the old, home orchard—a part of which remains and is now 55 years of age—annually threw out hints as to the possibility of apple growing in the valley of the Olentangy; that these hints the younger man, a lover and student of nature, from his boyhood, accepted as personal suggestions.

Twenty years ago one of the greater, blue grass pasture areas was set to apples. The sod, however, was unbroken save by generous excavations for the individual trees. Nature had suggested to

the planter that these trees should be given, as nearly as might be, the conditions under which flourished the great forest trees with which he was so familiar in his boyhood. If the accumulating, decomposing, protecting, moisture-holding carpeting of leaves could produce so great and grand a forest growth why should not fruit-bearing trees take kindly to the plan?

The young trees were mulched with strawy manure or litter at the time of planting. Thereafter the grass was cut and placed about them—widening the circle each year as the tops of the trees extended wider and wider. Little cinder-heaps were thrown about the bases of the trees and protected them effectually from the mice. This is a familiar story to many planters, large and small, who are following the grass-mulch system in many quarters of our state.



In a typical grass-mulch orchard.

The results of the method originating on this farm compose an interesting, true, successful, happy, serial story which is yet continuing with increasing depth and breadth and strength. It is a horticultural story over which the professional horticulturists of the country disagree and spar and hedge; yet they are one and all compelled to admit that the method is still winning success on this farm

and placing it in the foremost ranks of its kind of our country. This apple orchard, twenty years planted, has borne thirteen paying crops of apples. Twelve of these were consecutive crops without a season's break. Then there was a skip of one season, 1907, because of the killing of the blossoms by a late, spring freeze. This season, 1908, after one year's rest, the great storage rooms are filled to their full capacity. Upwards of 15,000 bushels of apples were harvested from the fifty acres of orchard. Not one percent was injured by the codling worm; there was scarcely any scab. Thorough spraying together with ideal cultural conditions afforded by the grass-mulch returned a crop that is worth a small fortune in itself. The trees are the picture of health and vigor and promise for the future. The orchard area is cleanly and softly carpeted with its smoothly clipped, dense matting of blue grass. No weather conditions which bring mud and slush and water are too bad to prevent one getting about the orchards with clean boots.

Thus has not only success been achieved in this unique and original plan of orchard management, but a lesson has gone forth from this farm which is living, growing, spreading and gaining favor wherever it has been fairly tested. The plan which has rendered it successful has helped in the solution of the cultural problems of many growers, great and small, less favorably situated.

The owner successfully stores his great crops of apples in private storage houses in the midst of his orchards. A lesson from his work and attainments in this line is not less valuable than from his cultural methods. In this feature of storage the independent thought and originality of the man is again quite manifest. As in cultural work, the chief and peculiar value of his plans lies in their practicability for the farmer and the small grower, as well as for the large orchardist.

The visitor at this fruit farm may observe, first, ice storage with the regulation, overhead ice chamber; second, a combination of ice and cold air ventilation with the ice boxes in the storage room; third, the cold air ventilation system alone.

It is not necessary here to explain the ice storage, as it is the system generally in use in all private storage plants. This is used for holding the early ripening varieties of apples—those maturing before the season of cold frosty nights comes, which renders possible the utilization of cold air for securing and maintaining a sufficiently low degree of temperature to safely keep the fruit.

The combination of ice and ventilation is an interesting plan and practicable for all who have access to ice in moderate supply. This system has been installed in the basement of a great barn.

The barn was built on the summit of a knoll. The excavation for the basement cut entirely through this knoll, leaving similar approaches and elevations at the two ends, and ample room to drive through from end to end with team and wagon. In addition to the semi-cellar-like conditions obtained by this plan, the basement walls and ceiling were papered and ceiled, leaving dead air spaces, and the floor cemented. Previous to putting in the apples (which are all stored in crates), a good grade of building paper was spread upon the cement floor also, as this had been found to prevent withering of the fruit which came into close contact with the dry, moisture-absorbing surface of the cement. The ice storage chambers, of which there are two, are probably 12x12 feet square with a height of about 8 feet, and are located some distance from either end of the storage room. There are open spaces of a few inches beneath these boxes, from which issues, driven by the accompanying system of ventilation, the cold air which leaves the under surface of the ice boxes. The warmer air, as it rises, is carried off through openings in the ceiling. The openings at either end of the basement are provided not only with tight-fitting doors but with heavy, wire screens. Previous to and during the season of picking the later keeping varieties of winter apples which are held in this storage, the tight doors are thrown open during cold nights, leaving only the wire screens. The circulation of the cold air from the outside cools walls, ceiling and floor of the storage room. The tight doors are shut during the higher temperature of the day time. The inside temperature is thus gradually lowered, assisted by the ice boxes. A temperature of from 38 to 40 degrees can be maintained in late autumn and early winter and a still lower temperature after cold weather comes. A dangerously low temperature in cold weather is rarely attained because of the earth-warmth of the central, "below-ground" portion of the basement. At the time of my more recent visit, November 13, 1908, there were about 8,000 bushels of fine apples in this storage—all neatly and compactly stored in crates.

A third storage, also utilized in the preservation of the later sorts of winter apples, is cooled by cold air alone. The walls of this building are double and constructed of hollow brick. The space between is filled with mineral wool. The owner states that if he were to build again the construction would be a frame one with double walls and the intervening space left empty. The building is set up off the ground a few feet. In the foundation are several openings or windows provided with tight-fitting shutters. In the floor of the storage room are four long, narrow openings covered with heavy, wire screen. Ventilating shafts extend from the ceiling to the peak

of the roof, which may be opened or closed at will. This storage room is cooled down at approach of apple harvest by opening the cellar windows on cold nights; the ventilator shaft to the roof is also opened. The cold air rushes into the cellar and up through the openings in the floor to take the place of the warmer air which escapes through the ventilating shaft at the ceiling. The room becomes very cold during the night. All openings are kept closed during the day time when the outside temperature is warmer. This storage has done very satisfactory work.

From the last described system of cold air ventilation there are few home owners but who can obtain ideas which should enable them to convert some out building, basement or barn cellar into an excellent storage room for winter apples, potatoes and vegetables.

As usual, on my visit of inspection to this fruit farm, observation was made of the methods of orchard pruning in practice. The owner favors low-headed trees. He is a disbeliever in unnecessary, heavy pruning, or restriction, to keep the trees within bounds as to size. He prunes about once in three years, thinning out the branches which are becoming too thick. With his low headed trees the upper, side branches are gradually extending outward from successive annual growths and are year by year pressed closer and closer to the ground by their weight of fruit. Retaining this position to quite a degree the lower branches are gradually overshadowed and smothered out by those above through cutting off of the sunlight. These lower branches are then removed.

When large branches are removed, they are cut off at a distance of perhaps 18 inches from their base, leaving a stump of that length. This practice frequently brings our friend into argument with professional horticulturists; but the vigorous manner in which he defends his ideas and the illustrations in the orchard which he points out, are quieting if not convincing. He contends that the removal of a large branch by sawing close to the body of the tree invites decay, while by leaving a stump of a foot or more, the stump dries or seasons out hard and sound and remains for many years without decay. He points out certain trees damaged and decaying through close cutting of large limbs. The argument is "clinched" by leading the visitor to a large and old apple tree which now has a hen's nest in the hollow resulting from the wound caused by close cutting of a large branch.

The writer agrees heartily with this orchardist on several important features of orchard work, but we cannot quite get together on the subject of pruning. It has been proved that large branches

can safely be cut reasonably close to the body of the tree if the wound be sterilized with a solution of copper sulphate, corrosive sublimate or carbolic acid, and given a heavy coat of lead and oil paint as soon as the solution has dried. The result is much more slightly, and heals over in time.

Another excellent orchard practice noted in this apple orchard was the treatment of trees which were splitting or threatening to split down from their burden of fruit or as a result of heavy wind.

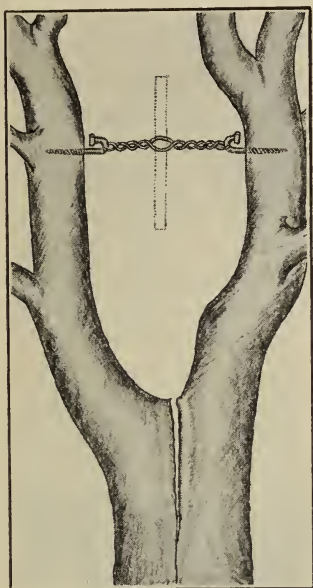


Fig. 6. Repairing a tree injured by wind or too great weight of fruit.

There are purchased what are known to the trade as "lag" or "coach" screws—large, square-headed screws which can be gotten in various sizes. Those preferred are six inches in length and three-eighths of an inch in diameter, which I find are priced at \$1.28 per 100, or 20 cents per dozen. A blacksmith turns a hook at the head-ends of the screws. Holes are bored in the two parts of the tree which are separating, in which the screws are solidly turned, connecting them with a heavy wire cable. The screws should be given such a position that there will be a "straight pull" on them, thus eliminating danger of splitting the branch. The cable is formed by using two "rounds" of heavy, galvanized wire from hook to hook, which is then twisted up taut by inserting between the wires a piece of buggy spring or other flat piece of iron or wood, and turning until the divisions of the tree are brought in close contact at the point of separation.

A PROMISING ORCHARD IN SOUTH-CENTRAL OHIO.

It is always gratifying to those engaged in Experiment Station service to be able to take up those lines of work which promise to appeal to the private culturist. It is pleasing to know, from the private worker's own lips, that such experimental work has helped to solve individual problems on the farm or in the orchard or garden. These words of commendation, it is good to affirm, come occasionally to the Station's Horticultural Department; they are much appreciated, as they tend to lighten burdens and brighten lives which are being earnestly devoted to the cause of horticulture.

It is especially gratifying, even though the knowledge is sometimes tardy in reaching us, to find that here and there, within our state, studious men who observe the Station's work very closely through its publications, are carefully, though quietly, following its advice, benefiting by its failures as well as successes, and escaping loss by its timely admonitions.

An illustration of this quiet, confident following of our Station's experimental work, takes us, for a short time, among the hills of western Muskingum county, which locality is typical, physically, of conditions prevailing in the hilly sections of south- and east-central Ohio.

In August, 1908, a gentleman who is a well-known physician of Cincinnati, wrote from his old home at Hopewell, Muskingum county, where he was spending his vacation, reminding me that we had met at the Troy meeting of the Ohio State Horticultural Society, in 1900, at which time he was becoming not a little interested in fruit growing as a commercial proposition. He extended an invitation to the writer to visit the old homestead at Hopewell and see what had been done since the year 1900. This invitation was accepted and resulted in a visit early in September, 1908.



Fig. 7. A promising young orchard in which the grass-mulch method of culture is faithfully followed.

The correspondent's seven-year-old orchard is situated south of Hopewell, a village on the old National road, nine miles west from Zanesville. This is one of the high points of the state—the elevation as indicated by a recent geological survey, at one corner of the

orchard, is 1126 feet above sea level. This particular elevation forms the water-shed or "divide" between the little streams of water flowing north and north-east to the Licking river and those flowing south to join the Moxahala or "Johnathan's creek."

Here was found, in a section where there is little interest in orchard planting, one of the finest and most promising young apple orchards which it has been my privilege to examine in Ohio. Here were growing over 2000 trees of four varieties—York Imperial, Rome Beauty, Grimes and Ben Davis—all scrupulously neat and well kept under the sod-mulch or grass-mulch system of culture, of which this orchard is an excellent example.

The owner's experience in starting this hill orchard and attempting to cultivate for the first few seasons, would serve as an admirable lesson to those who refuse to recognize anything but persistent, annual plowing and cultivation. The surface of the orchard area is all sloping; much of it is quite steep. Various exposures are represented—all inclining toward a low depression or ravine having its exit at the south-central limit of the field. The character of the soil is almost as varied as are the exposures and is representative of a large portion of eastern and southeastern Ohio where the various strata, through erosion, exhibit their different, decomposing layers on hill slopes. This section embraces the western limit of the bituminous coal fields underlying eastern Ohio, and an excellent grade of this variety of coal underlies this farm where coal mining for local consumption has been in progress many years.

The field, previous to planting to apple trees, was covered with an unsightly growth of briars, shrubs, weeds and mixed grasses. The ground was cleared off, plowed and prepared as for a field crop. The trees were set and a crop of corn grown between the rows each of the first two seasons. At the end of two seasons' cultivation the mistake made was only too apparent. Great gullies were being cut and a serious loss of soil sustained by washing during heavy rainfall. Clearly this would not do. Something must be done to check the frightful erosion. A sod must be grown or the orchard would be lost and the ground ruined for all time. A vigorous effort to secure a catch of grass was made, extending throughout the next two years, when success was finally attained by fall seeding. An excellent carpeting of timothy and clover and mixed grasses now covers the ground. This is cut and used for mulching the trees. In the better portions of the orchard this growth is not only sufficient to heavily mulch the trees in that section, but there is some material to spare to be used in the thinner places. If there be not

enough grass to mulch all trees thoroughly, straw or other material is brought in from other sources and every tree well mulched. The entire orchard would be a credit to any experiment station as an example of the grass-mulch plan of culture.

There was much difficulty experienced in getting the gullies stopped which had been cut by the water during the two seasons' cultivation. Many loads of brush and other coarse material were hauled in to fill the channels which were too wide and deep to be safely crossed by a team. Even stones and soil had to be hauled to restore and hold young trees which were literally "washed out by the roots." Trees that had been undermined and had fallen toward the gullies and which had been pushed back and blocked with soil and stones and brush, were pointed out. One of these trees is shown in the photograph accompanying, after the gully has been filled and grassed over—the second tree at the left hand.



Fig. 8. Where great gullies formerly abounded.

An experience of this kind would be a valuable educational feature to the advocate of persistent plowing and stirring of the soil, who never learned the lessons which our steep hill-sides are capable of "rubbing into" the student horticulturist. It is simply folly of the grossest sort to recommend cultivation under such conditions.

Considerable trouble has been experienced in this orchard from the work of rabbits, wood-chucks and field mice. As usual the mice are the more destructive of these enemies. Mounding with soil, cinders or fine coal screenings from the nearby mines is now practiced with good results. The effect of partial girdling by mice, becoming apparent by the early and heavy fruit-bearing of the trees

most injured, is to be seen here and there. The orchard as a whole is now beginning to produce a small quantity of its first fruits; but the partially girdled trees were this autumn bowed to the ground by their heavy loads of highly colored apples. Many of the trees injured promise to outgrow the wounds; some will die. There will probably not be further injury done as mounding is now to be done annually.

There are not a few neighbors of this old homestead who are inclined to smile at this venture in orcharding in a section where commercial fruit growing is practically unknown. But, with the present good care, the time is not far distant when this same orchard will be an object lesson in successful commercial apple culture in its vicinity and among the leading ones of its kind in Ohio.

Conditions in Muskingum county are similar in many ways to those in southern Ohio which is noted for the beautiful color and fine quality of its apples. In some respects south-central and east-central Ohio are superior to the extreme southern or eastern parts, for apple culture. The elevation above sea level is as great or greater; the hills are not so extremely steep; the soil, as a rule, is better and more productive; the trees make a larger growth and are longer lived; and, on the sunny exposures of the hillsides and tops, the coloring of the fruit and the quality are fully equal to that attained in more southern areas of the state.

The only criticism which I should care to offer in relation to orchard practice observed at Hopewell is the plan pursued in "pruning up" the young trees. The lower branches have been pruned away, leaving those of more upright growth to form the heads of the trees. The young trees are low-branched, naturally, which will enable them to outgrow the effects of this pruning up in a few seasons. True, the time would come when these lower branches would have to be restricted or perhaps pruned away entirely; but they might well be allowed to remain until the branches above, through being borne down by weight of fruit and set in that position, have so overshadowed and crowded them as to render them of no further use either in shading the body of the tree or in fruit production.

HORTICULTURAL ACHIEVEMENTS IN SOUTHERN OHIO.

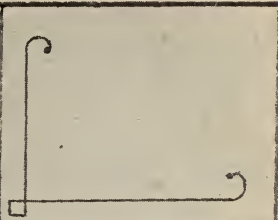
Mention has been frequently made, in this report, of the prominent place in fruit culture occupied by the southernmost part of Ohio. While it has not, at any time, even been suggested that a recital of orchard practices in this extremely hilly section could be of material benefit to the well and modernly equipped orchardist of northern Ohio fruit districts, there are yet lessons to be learned

concerning the peculiar resources of our state; the fidelity of some of her citizens to environments which have been their inheritance, and certain methods which, if one-half so faithfully observed, should bring success to the smaller producers in the central and somewhat less hilly areas.

The extremely broken character of this section, physically, is evidenced by the fact that there is an oblong-oval tract of land some 24 miles wide by 40 miles in length, extending lengthwise north and south, which has not, as yet, been penetrated by a steam or electric railroad line. This tract embraces the larger portions of both Lawrence and Gallia counties. The rough character of the surface of this land cannot be said to be caused by "high hills;" more properly it is due to its deep, steep-sloped ravines caused by erosion—the cutting down and wasting away of the land by the excavating power of the Ohio river and its numerous smaller tributaries.

The surface of the country now embraced within the lower three-fourths of Ohio was, in earlier ages, practically a monotonous plain with a very gentle slope southward from the watershed or divide—a ridge extending from the north-east part of the state south-west to a point midway of the north-and-south, Ohio-Indiana boundary line. The hills in this southern Ohio section are not, therefore, of greater elevation above sea-level (they are slightly less) than those farther north. The erosion or "washing" has only cut deeper, sharper, broader depressions which cause us to exclaim at the apparent height—the dangerous steepness of the hills. The magnitude of these depressions or ravines can best be realized through a simple illustration: At the writer's country home in south-central Licking county which is very nearly the central point in Ohio, there is a flowing spring of water which is one of three forming the source of one of the creeks tributary to the Licking river. This spring is at an elevation of about 1025 feet above sea level. The little stream flowing away from this source can be followed in a very winding course to the Licking; the Licking to the Muskingum; the Muskingum to the Ohio; the Ohio to Huntington and Rockwood at the southern point of Lawrence county. In all this meandering course of fully 250 miles via Zanesville, Marietta and Pomeroy, the waters of the little stream are constantly flowing to a lower level. The fall is slight in places, in others it is abrupt; but it is ever dropping lower and lower. Yet the summits of some of the southern Ohio hills are but slightly less in elevation above sea level than the source of the little stream in central Ohio. The descent from these elevations to the

bed of the Ohio river opposite Huntington is difficult of conception save by the personal observer. We are told that the loftier hills which may be sighted from the river range from 200 to 600 feet above its bed.



Rome Beauty apples

The old Homestead of Nelson Cox, deceased

Photos by Ethel Cox.

Strange to say many of these steep hills were early denuded of their timber and cropped to their fullest capacity for many years subsequent to the civil war. But, as the humus or decomposing vegetable matter with which the virgin soil was filled, became depleted by indiscreet cultivation, the soil was more and more readily swept away from the steep inclines by the washing rains. Stripped of the protecting forest growth the terrible erosion characteristic of former ages was again resumed and in many places is yet continuing.

The rougher hills of southern Ohio do not present the beautifully rounded outlines of those in more northern regions of the state; many of the steeper slopes expose barren, yellow areas slashed with gullies; others are covered with briars, shrubs, weeds and thin growths of mixed grasses. Small areas here and there still support original growths of native timber; and these suggest the part southern Ohio hills might be playing in the commercial world today had they not been carelessly and wastefully denuded. Other areas are slowly reclothing themselves with forest growths. Among these the Black Locust is conspicuous and is producing great numbers of posts for a ready market.

It was in 1854, before the timber had been so largely removed from the hills; before there had occurred so great a waste of the resources of the soil of the hillsides, that Nelson Cox came across from Cabell county, West Virginia, settled in Lawrence county and laid the foundations of the fruit growing industry in southern Ohio. Eminently successful, respected and honored by all who knew him and living to the age of seventy-four years, he was privileged, prior to his death which occurred October 30, 1902, to see gathered over 3000 barrels of beautiful apples from trees planted by him on the old homestead.

Southern Ohio orchards are scattered over the steep slopes and towering summits of hills such as I have endeavored to describe. At first sight they are disappointing to one who goes to this section from the northern fruit country expecting to see great blocks of uniform trees in straight alignment up, over and across the hills. Such planting is not practicable here, no matter how desirable. So steep is the ground that, to enable the orchardist to get about with cart, wagon, sled or mower, the rows must encircle the hills, preserving as nearly as may be, a right angle to their slopes. Even then, in the more dangerously steep places, a furrow is drawn between each two rows of trees, in which to run the upper wheels of wagon or spraying outfit to prevent overturning. Moreover, on account of the fact that on this character of ground the trees are comparatively short-lived, replanting must continually be in progress. All orchardists know that loss of trees and replanting soon breaks the uniformity of the most sightly orchard plantation. Loss of trees and replanting here, however, do not mean as many years of waiting as is the case in the more northern sections, where the soil is stonger and where the impulse of wood growth, for the first few years, precludes the possibility of early fruit bearing. Just what peculiar quality it is, possessed by this thin ground of the southern Ohio hills, which coaxes newly planted

trees almost immediately into fruit-bearing, I have never heard satisfactorily explained. This, however, is true; and it is not unusual to see small, shoulder-high apple, peach or plum trees, bearing great well-formed specimens of their kinds, entirely out of proportion to the diminutive trees bending under the weight of their burden.

The standard of orchard cultivation, in this section, is not that which quite satisfies the scrupulous culturist, cover-cropist or grass-mulchist of more easily travelled orchard areas. But the considerate, sensible horticulturist will concede that it would be difficult to introduce a method that would safely combine the essentials of thorough, cultural practice. It would be the height of folly even to seriously think of plowing such hillsides. Gullies which are with difficulty held in check are already in evidence. In rainy seasons every inch of soil loosened by successive cultivations would eventually add its contribution to the delta of the Mississippi, leaving the hillsides stripped of the little organic matter which many seasons have been accumulating. Mulching, while desirable in the highest degree and successful on the hills wherever it has been tested, presents grave difficulties in this hilly section where practically no grain is grown, hence no straw procurable within reasonable distance. Straw may be purchased over in the valley of the Ohio, but the price is high and the eight or ten or more miles of rough, hilly roads are a barrier to transportation. Straw, even under these expensive conditions proved, in an experiment under the direction of the Experiment Station, to pay well when applied as a mulch. Eight dollars per ton were paid for this material for mulching. The trees thus treated suffered less from drought, held their foliage better and perfected finer crops of fruit than adjacent trees not so mulched.

The thin, orchard soil, as a rule, does not produce a sufficient growth of grass to make an effectual mulch for the trees, when cut with the machine or scythe; it is clipped once or twice in a season and allowed to remain where it falls. This seems to be about the only course open to the orchardist of this hilly section. To the credit of these orchardists they do not claim that they are thus following the true grass-mulch method, as have certain others who pursue this plan of orchard management; they are merely doing the best they can under the conditions with which they have to deal; and the peculiar environment among these rugged, sunny hill-slopes, brings generous response for their arduous labor.

No definitely outlined system of pruning is followed in this section; and little pruning is done as compared with the more northern fruit country. Indeed much less pruning is required

here where the trees come into bearing at so early an age. Fruit bearing at once checks, equalizes and distributes uniformly over the tree the production of new wood—thus shaping at a very early age a mature form of tree. This early maturity in form and precociousness in fruit bearing would, in the more northern latitude be regarded as prematurity—as abnormal—and we should at once be led to examine the base of such a tree for borers, injury by mice etc.; for only a girdled tree, in central or northern Ohio, presents this phenomenon of early maturity and abundant fruit production which are brought about by quite natural but little understood causes in more southern parts. In the north, on rich soil, the annual growths of wood are so rampant and upright, and fruit-bud formation so much longer delayed that more or less restriction of growth must be resorted to in order to hold the heads of the trees within reasonable bounds vertically and laterally. Such restriction by pruning means a multiplication of shoots and these, in turn render thinning of branches necessary.



Fig. 10 Spraying apple trees among the southern Ohio hills.

Photo by J. S. Houser

The writer has a half-dozen trees of the Ensee apple, in Licking county, six years planted, which were propagated in Southern Ohio. These trees have not yet borne a single specimen of fruit, nor has

it been expected of them; but very small trees of this variety, not half so long planted, were seen this season (1908) in Lawrence county bearing one or more fine apples. The same tendency to early bearing is found in other classes of fruits.

The apple trees of this southern area are, as has been before stated, comparatively short-lived from early, profuse and regular fruit bearing. In consideration of these facts it is clear why a well defined system of pruning has not been developed in this section.

It cannot be marvelled at, therefore, that the energy of the southern Ohio apple grower is largely expended upon spraying and thinning. These constitute the secret of success aside from the peculiarly propitious, natural properties of soil and climate. Faithful devotion to spraying atones for any compulsory omissions in culture or pruning. In spite of the dangerous and, in some places, well nigh inaccessible slopes, the gasoline spraying outfits are almost continually creeping around, over, up and down the rough orchard areas, dealing out death and destruction to insects and fungi infesting foliage and fruit. This brings soundness of fruit and that tenacious, "clinging" quality which keeps it on the trees until late in the season, permitting the southern Ohio sunshine in conjunction with the peculiar properties of the soil and elevation, to perfect the work of exquisite coloring for which the fruit of this locality is widely noted.

The Rome Beauty apple which reaches so high a degree of perfection in southern Ohio, originated in Rome township, Lawrence county. Other seedling trees are found springing up throughout this older apple section. Emanating as they do, in many cases, from standard varieties of excellence, a number of these seedlings possess some merit. So far unapproached among these is the "Ensee" (N. C.—Nelson Cox) the seedling tree of which came up near the site of an old cider press on the old homestead. The tree stood and bore regularly and heavily, for years, near the barn. The writer was privileged, two or three years ago, to see this tree bearing a crop of over 30 bushels of fine apples. Soon afterward the barn burned and the tree perished. The "Ensee" in general appearance, somewhat resembles the Rome Beauty of which it may be a seedling; but the quality is vastly superior. It has won many prizes on the exhibition table, for size and beauty and for dessert quality.

FRUIT PRODUCTION FOR THE RETAIL MARKET

There is sometimes a tendency, in studying or describing the resources of a country or state, to patronize those sections and press to the front those firms and individuals which are most extensively engaged in the industries under special observation, to the neglect of the lesser enterprises of the same type which are in successful operation in many places. It is desired that, throughout the various chapters of this report, there shall be distinctly traceable a current of recognition of the simple interests of the home owner and smaller grower of horticultural products as well as of the greater industries of special horticultural sections.

Representative of the retail branch of the horticultural industry in Ohio, and of conditions and possibilities prevailing in the central portion of our state, there was studied a fruit farm located on the northern border of the valley of the Licking river, five miles north-east of Newark, Licking county. A brief description of this business is deemed advisable simply from the fact that such a recital may be the means of suggesting some point which may prove helpful to others who are endeavoring to build up a first-class retail trade in other markets of the state.

It is the purpose at this farm to be able to offer to customers, throughout the entire year, the choicest fruit products of the soil, put up in the most attractive form. A diligent study is made not only of the principles of horticulture and soil management, but of varieties and types of the different classes of fruits, which embrace those superior attributes which satisfy the more exacting. As a result of this study not only is the standard of excellence in various products steadily and surely promoted to a higher plane, but there is a corresponding educational advancement of the patrons who year by year more fully appreciate the difference between the superior and the inferior and are willing to pay for that difference. No longer is an apple "just an apple" nor a potato "merely a potato" regardless of individual, varietal characteristics which combine to produce a good or a poor product; and it is this generally increasing distinction between high and low quality, and the fuller appreciation of the effort to place goods upon the market fresh and crisp and in neat and attractive and appetizing form, that render marketmen of this type (and there are many of them) successful at the present and hopeful for the future.

The market season opens, at this farm, with rhubarb and asparagus and continues throughout the year, including strawberries, raspberries (red and black), blackberries, currants, gooseberries, grapes, cherries, plums, peaches, pears, summer, fall and winter

apples, melons and potatoes. During the summer months the market stand is at all times brightened with out-door-grown, cut flowers of the various kinds and seasons. Chief among these are sweet peas, gladioli and dahlias. From the sale of flowers quite an additional sum is realized during the season, aside from the attractive feature they afford.

The retail market bench which represents such a farm never becomes a "bargain counter" in the generally accepted sense of the term. Great quantities of produce are sold to the consumers and always at the highest, prevailing market price. Many private orders are taken for considerable quantities for home use and the delivery of these larger lots, together with a brisk wholesale trade with a number of the leading grocery firms, render busy the days intervening between the semi-weekly markets.



Fig. 11 A central Ohio strawberry field

Central Ohio horticultural conditions, fairly well represented by this farm and business, are favorable to the production of nearly all classes of fruits. The exceptions should, perhaps, be peaches and pears which flourish only in certain small areas where soil and climatic conditions are exceptionally good. "Peach yellows" and "fire-blight" of the pear make the growing of these desirable fruits most discouraging. These diseases seem especially virulent in

central and southern Ohio. At the farm visited the owner has recently cut out many peach trees which were just attaining fruiting age, while pear trees are blighting and dying upon every hand. Whether the generally prevailing light, gravelly nature of the soil is, in part, accountable for this serious loss of pear trees, is a question which suggests itself. The land, part hill and part level, includes sections of both the sharply sloping coast and the comparatively level bed of a great prehistoric lake which covered what is now an extensive area in central Licking county. This, together with the fact that it is quite near the southern limit of the glaciated area of the state at this particular point, probably accounts for the peculiar and gravelly character of the soil.

The orchard areas include the steeper exposures of the hill section of the farm. Of necessity some form of orchard culture that would conserve the soil itself as well as the soil moisture, had to be adopted. The fruit trees, on the hill-sides, occupy strips of grass-land extending along or around the slopes and at right angles to the direction of the descent. The grass growth is clipped from these strips and utilized, so far as it will go, in mulching the trees. All other surplus vegetable or weed growth is utilized in like manner. Straw is also purchased for mulching trees and strawberries.

Bush fruits are largely grown between the tree rows—these intervening strips being cultivated during the earlier part of the season and sown to some cover-crop later on. Potatoes and melons are also crops grown between the tree rows and are used in rotation with leguminous plants such as cow peas, or Canada field peas sown with oats. It is clear, therefore, that where plowing and cultivation of the spaces between the tree rows, on the hill-slopes, has been practiced, it has been done in connection with the growing of these as a money or a leguminous crop—both of which mean practically the same thing to the horticulturist. The strips of sod break and catch the wash of soil, and the repeated plowing of the ground—always turning the furrows downward—is gradually terracing the hillside and forming more level road-beds between the rows so that there will be less difficulty in getting about, in later years, with team and wagon or sprayer.

Independent bush fruit plots and the vineyards are cultivated annually, finishing each season's culture with the sowing of some cover crop to retain the soil and conserve and utilize such elements of fertility as would otherwise be lost through washing, or escape in gaseous form.

Grapes of most excellent quality are grown on the sunny, southern slopes, and afford a most attractive and tempting addition to the products filling the market bench, during a long season.



Fig. 12 From tree, plant and vine to consumer

Strawberries and potatoes are companion crops on the lower, more easily and safely tilled portion of the farm. A favorite rotation is strawberries, crimson clover and potatoes. In addition to the Crimson clover as a soil improver, and stable manure, commercial fertilizer containing a heavy percentage of phosphorous is giving excellent results with potatoes. In past years it was thought that late planting of potatoes, in the hilly section of central Ohio, would bring only disappointment and loss. The introduction of commercial fertilizers is causing a happy revision of that theory. Phosphorus in the form of "acid phosphate" so hastens development and maturity of the crop that potatoes, even of those varieties which are medium to late in season are now planted as late as June with good results. The season of 1908 exhibited the advantage of late planting, in central Ohio. The first part of the season was cold and rainy and the earlier planted potatoes generally showed much scab at the time of digging. The latter part of the growing season was quite dry; and while the June-planted crop did not yield so many tubers per hill, the individual tubers were of fine, large size, smooth, and unusually free from scab. They matured in ample time to be harvested before serious injury by frost. Eliminating the maturity-hastening element—phosphorus—from potato culture, when planting is done so late and in so dry a season, the product resulting, in this section, would hardly have exceeded in quantity the seed stock used.

As before intimated, good quality in potatoes is not less regarded than good quality in fruits. The reputation of this farm for high class produce is built, in part, upon the Seneca Beauty potato for which there has been developed an excellent private demand.

While the business of this farm is quite extensive for one from which retail marketing is made a special feature, yet it is so representative of what may be done on the smaller place in connection with the home market, that it is with pleasure that this chapter is added to our report.

In conclusion, it is often asserted, and reasonably, too, that fruit growing is fast drifting into the hands of specialists. With an ever increasing host of insect and fungus orchard enemies to combat, it could not do otherwise. This is providing we properly interpret the term "specialist." The question arising is—what are the characteristics of the "specialist?" If the "specialist" is supposed to be represented by growers both great and small, who intelligently and successfully plant, cultivate, prune, spray, harvest, pack and market their products of the soil, well and good. If the "specialist" is to be solely represented by those individuals or firms which conduct orcharding upon an extensive commercial basis, let our doubts assume the form of a protest. The time has not yet come when the wide-a-woke small grower cannot earn a comfortable living and a substantial home, if he have access to a good, home market, and he be willing to work with his own hands, while the extensive grower is building his fortune or a firm or company of growers earning satisfactory dividends upon their investment of capital. While the latter represents an essential factor in the production of the world's supply of fruit, the former is an equally important factor in the maintenance and multiplication of that class of country homes and enterprises which are the "backbone" of prosperity in the rural districts of our state and country.

PROTECTION OF TREES FROM RODENTS

In view of much inquiry submitted to the Horticultural Department of the Station, as to means of protecting orchard trees from the destructive work of mice and rabbits, observations have been made on the various trips in inspection service for the purpose of noting methods in use by large orchardists.

In those level parts of the state where orcharding is the more extensive feature of industry and, incidentally, where cultivation is practiced generally, there seems to be little trouble given by

rodents. An occasional tree may be gnawed by a stray rabbit, but these pests are by no means so numerous as in the hilly sections of the state, and little attention is given and few precautions taken to prevent the small loss. Banking or mounding the trees with cinders or soil, to prevent injury by mice was the only means of protection from rodents that were observed during the whole season of 1908, though orchards in several parts of the state were visited.

More in detail banking consists in maintaining at the base or about the "collar" of each tree a little mound composed of a few shovelfuls of cinders or of soil where cinders are not available. In case soil is used the little mound should be firmly "tamped" down each autumn and fresh soil added to round it up. Otherwise the old mound becomes burrowed full of holes during summer and affords good places of concealment for feeding mice in winter. Tamping, just before freezing weather, closes all burrows and compacts the soil so that no more will be made until after freezing and thawing is done the next spring.

It is evident, from correspondence, as well as through personal experience, that nine-tenths of the injury by rabbits and mice occurs in the small, isolated, home orchards, as surroundings are usually favorable to bringing these rodents into close proximity to the smaller, home plantings. In such cases the importance of some mechanical contrivance to keep the rodents away from the trees, cannot be over estimated.

A fully illustrated and descriptive bulletin is in course of preparation as a result of calls for help along this line.

THE OLD AND NEGLECTED ORCHARD.

There are hundreds, yes thousands of these in Ohio. The former owner was a lover of fruits. He gathered from various sources his trees and took much delight in planting and pruning. Many of these trees were of unknown and perhaps unnamed varieties. He did much budding and grafting of choice varieties on the trees composing his home orchard. He rarely cultivated; he did not spray; yet the rich virgin soil produced strong clean growths and the equilibrium of Nature, which had not yet been disturbed—thrown out of balance—rendered the problem of insect control a factor in fruit production not yet dreamed of. His children, as a rule, manifested much less interest in the orchard. They enjoyed the fruits which were usually in sufficient supply to meet their wants; but they gave little personal thought and care to the source of this bountiful supply.

There were few convenient markets of consequence demanding fruits and offering attractive returns which would awaken their interest in fruit growing as a business. Their thoughts and efforts were directed in other channels in pursuit of lucrative employment.

The planter under whose fostering care the orchard had flourished, reaches the zenith and proceeds onward toward the sunset of life. During his declining years the orchard, growing old with him, has had no special care. The great trees have grown beyond all anticipated bounds.. Some of them are dead; others are dying. Many scattering dead, broken and lodged branches render unsightly that which was formerly an object of symmetry and beauty. The owner dies. The mental record of interesting data relative to planting, care, crops and varieties perishes with him.



Fig. 13. Once the pride of a pioneer home.

A younger generation comes into possession. The old orchard is an eyesore. Cutting down and burning the trees is in contemplation. Yet there are a few fair specimens of fruit on the uppermost branches. Their maturity is awaited. The longest ladder proves by far too short to reach them. The danger to human life and limb is too great to attempt to climb for them. The axe and the saw are introduced as implements of the harvest. The great branches are sawed and slashed partially through. Gravitation accelerates the work of butchery. The heavy, fruit-laden

branches crash to the ground taking with them great slabs and splinters and strips of bark from the remaining, upright stumps. The fruit, bruised and crushed, is gathered up, unfit for anything but immediate use. The wreckage, complete, is left to be cared for later on; it will be used for fuel or allowed to remain as a temporary monument to the horticultural aspirations and attainments of the present generation. The ambition and enthusiasm in orchard ownership and orchard work which characterized him who has gone before has reached a low ebb in his offspring. Is there anything which can intervene to change the course of this progressive outrage upon nature—this willful destruction and absence of appreciation for the beneficent forethought and labor of the pioneer home maker? There is: "A little child (a little tree) shall lead them."



Fig. 14. A sad example of mutilation.

In following years, where a veteran tree had been chopped or broken off at the ground, new shoots have been annually springing up only to meet a hard fate from roving stock, or plow, or grubbing hoe, or scythe. By chance, which approaches the miraculous, a fortunate, vigorous sprout—a baby tree—from a decayed stump of a tree long gone, has withstood the vicissitudes of the pasture lot and attained the age of reproduction. Its first fruits instantly attract attention because of large size, excellent form and color and good quality. The dormant or scattered interests of the present owners are awakened and concentrated by this "phenomenon(?)" occurring on the site of the old orchard. What is this remarkable fruit? Is it a new variety? If so, a fortune at once shows its hazy

outlines in the indistinct future. Is it a new type of an old variety? Good fortune is still dimly seen to arise and shake herself. Is it an old variety, simply? If so, this particular location must be especially adapted to its production in the most excellent degree, else such great fruits would not grow upon so diminutive a tree. Good fortune is still in sight.

Who is there to help unravel this tangled problem? Some one has spoken of the Experiment Station. What is it; where is it; to whom should the communication be addressed? Help is called to assist in the identification of the variety newly fruiting, or in the determination of whether or not it is a new variety. Information is eagerly sought as to best means of propagating young trees of this particular species for planting. The previously little thought of processes of grafting and budding now become a special branch of education most seriously and earnestly coveted. Interest in all phases of orchard establishment and management is quickened into new life. Preparations are made for clearing away or thoroughly renovating the old orchard. New areas are chosen and staked out for the planting of young trees of this "special" and other varieties of fruits. All this, in progressive order, is the sequel of "the survival of the fittest" in the erstwhile abandoned home orchard.

Thus the springing up of a tree, a bush, a bramble, a vine or a plant the fruit of which embraces some distinctive quality which attracts and holds attention, has the power to lead the careless owner back to Nature; to return a younger generation to the interests, delights, enthusiasm and ambitions of its progenitors.

HILL-TOP GARDENING.

Aside from the new fruits found growing and flourishing in Richland county, there was observed both in 1907 and 1908 another horticultural feature which was interesting to an unusual degree. The writer has referred, in one of the initial chapters, to the fact that while in Ohio there are found great areas excellently adapted to the production of special crops, there are at the same time smaller, widely distributed areas, throughout the state, where the same crops can be grown in great excellence for home use and local market. So far as vegetable production is concerned the gardens of a leading horticulturist near Mansfield are representative, in a measure, of still another class which is producing certain crops (at a profit too) under conditions generally regarded as decidedly unfavorable for such crops. I refer especially to the growing of celery by this gardener, for which he enjoys an enviable reputation.

This place is located in the southern suburbs of Mansfield, on one of the hill-tops overlooking the main or business portion of the city. While the location is an ideal one for tree and small fruits, because of its high elevation and immunity from frosts in late spring and early autumn, vegetable growing, especially in a dry season is attended by some difficulties not fully realized by the valley gardeners.



Fig. 15. Upland grown celery.

The truth that this man is accomplishing some unusual results on his hill-top soil promptly suggested itself the first time the writer was privileged to take a meal in this hospitable home. A great dish of tempting celery occupied a prominent place on the table. The individual stalks were slender and delicate—very different from the coarse, stringy product of some of the low, moist or peat soils. The quality was found to be superb. The stalks were tender, crisp, fine in texture and most delicately flavored. Inquiry brought out the interesting fact that the peculiarly fine quality of this upland-grown

celery rendered it difficult to produce any where near enough to meet the demand of the local market upon which such produce is retailed over the private bench. Stalk for stalk it would outsell the larger, coarser types from the moist, low lands; therefore, the lesser bulk did not represent a proportionate financial loss by any means.

The appreciation of this feature of gardening under unusual conditions, was taken to heart and carried home with the writer in 1907, and often commented upon when the subject of celery was under discussion. In 1908, during the second visit, I was careful to purchase a generous lot of this particular quality of celery to carry home. A season of enjoyment followed at the close of which a general discussion of "hill-top" celery would terminate only in a prevailing wish that occasions might frequently return when, while waiting on trains in Mansfield, a certain market bench might be again visited.

The lesson which we particularly desire to bring out in this chapter is that there should be an earnest effort put forth to determine if we as home and land-owners do not, after all, in our supposed unfavorable surroundings and conditions, possess some peculiar requisite to success in one or more lines of work or the growing of one or more kinds of produce, that will well repay us for our outlay of time, energy and capital.

This gardener does not necessarily have to grow celery. Other kinds of produce can be grown more easily; but the very difficulty which he meets in celery growing gives to his product a quality all its own—one which represents the difference between profit and loss and one which renders it eagerly sought by discriminating buyers.

POTATO GROWING IN THE HURON VALLEY

On August 13, 1908, a visit of inspection was made by the writer, to the lower valley of the Huron River, Erie county, for the purpose of observing conditions under which potato culture is becoming an industry of considerable importance.

Nature has accomplished a marvellous work in preparing this valley for occupation and cultivation by man. It is bordered on the east and south-east by the great eminence of Berlin Heights upon whose rugged slopes are to be seen unmistakable evidences that this was, in the glacial period, a region of wonderful activity—of terrific impact—where rock of Gibraltic resistance paralleled accessible and inviting thoroughfares for the merciless, grinding mass of snow, ice, earth and granite. Such an avenue for the onward,

southern progress of the Arctic conglomeration was the depression which is now the valley of the Huron. Levelled by the advancing bulk; thickly veneered with drift clay from the receding, melting mass; covered with sand and loam through later iceberg agency and erosion of rock and earth; for ages beneath the fresh waters of the great lake which, following the glacial period, covered much of the land now embraced in the northern part of our state, the present basin of the lower Huron is supporting thousands of beautiful homes and feeding other thousands of citizens of our own and other states, with varied products of the soil.

The soil of the valley is, as before stated, for the most part, a fertile sand, deep, dark and underlaid by a stratum or sub-soil of clay. It is therefore porous and retentive of moisture, yet readily cultivable in a surprisingly short time after heavy rainfall. These conditions favor, in the highest possible degree, the use of labor- and time-saving implements for breaking, preparing and cultivating the ground, as well as for planting and harvesting the potato crop. The cost of production is thereby reduced to the minimum. Fields of from 10 to 25 acres were observed which were clean of weeds and in an ideal state of cultivation, in which no hand work whatever had been done. The land being level, there is no loss of soil or fertility by washing during heavy rains.

Two hundred bushels of potatoes per acre, it was stated to the writer, can be averaged on considerable areas of the better soil of this valley in ordinary farm rotation of crops and without special fertilization. Indeed it seems to be a question in the minds of some of the larger growers whether the results of the application of commercial fertilizers will justify the cash outlay. Barnyard manure is, of course, used by those to whom it is available, and with good and lasting results.

So far, however, but little in the way of systematic experiment has been attempted, in this section, to test the results of using the separate or combined, commercial elements of fertility. A certain grower near Berlin Heights is planning to extend his fertilizer work and to take up variety testing under the supervision of the Experiment Station. This young man is somewhat skeptical as to the advisability of drilling in expensive applications of commercial fertilizer over the entire area of the ground, under his conditions, where, on naturally fertile soil both clover and barnyard manure are used in the farm rotation. He insists that if a small quantity of high grade fertilizer be used directly in the row, beneath the seed pieces, as applied by the leading potato-planting machines with fertilizer attachment, the results will be equally good. He

considers that, with this bit of readily soluble plant food right at hand and quickly available to the young plant, no other special fertilization will be needed; for his soil is already well supplied with every element necessary to the development of a heavy yield; and that this well distributed store of food is entirely sufficient for the demands of the plants so soon as the rootlets reach out after it. This question will probably become a problem for solution on this particular character of soil in the future.



Fig. 16. A Huron Valley potato field

But few early potatoes are at present grown in the valley of the Huron. Those who have the hardihood to attempt the role of "the early bird" are said to be the *victims* rather than the *captors* of the *worm*. This seemingly discouraging feature is not, however, one that is especially peculiar to the locality. There is only one reason urged why the Huron valley does not produce early potatoes equally as well as the more noted early potato sections of Ohio. This reason, the Huron potato farmer will tell you, "is because the Colorado beetles almost invariably destroy the early-planted potatoes!" In support of this statement the writer readily admits that he observed a field of probably ten acres in which nothing was left but bare stems. Not a bushel-basket of foliage, I dare say, could have been gathered from the entire area. The simple reason for this beetleistic supremacy over man is that the man has so far shown no disposition to vigorously contest the right of the beetles to destroy his crop. No spraying has so far been done except in a small way where potatoes for early use in the home, are grown.

This apparent indifference to the serious consequences of unrestricted insect infestation can be explained by the fact that if planting be deferred until late in the season there is practically no injury to the crop by beetles. Just why this should be true in this particular locality more than in other parts of the state, I am at a loss to understand. In the central portion of Ohio, in the season of 1908, a most serious and persistent infestation by Colorado beetles occurred in August on the late planted potatoes, necessitating a battle royal with sprayer and strong arsenical poisons, to clear the plantations.

The laxity of effort in insect control, in the Huron valley, in itself serves to emphasize the statement that in this section the potato is considered to be so much at home that no radical measures need be adopted to bring it to perfection. If failure result through insect infestation or fungous disease the loss is more likely to be attributed to abnormal conditions rather than to lack of effort on the part of the planter to combat such troubles. The truth remains that the loss of income to the growers in this section, through the disposition to permit the Colorado beetle to dictate which class of potatoes shall be grown and the season at which they shall be planted, is a loss which by no means need be accepted as an inevitable heritage of the Huron potato grower. A short, sharp skirmish with a good four-row sprayer as an engine of destruction, at the critical period, viz., just as the larvae are hatching out, would mean the finish of the beetles and a generous yield of potatoes for the early market.

The menace of early blight (and this should not be confused with "tip-burn" or sunscald of the foliage—a curling of the leaves from the margins) is another hindering factor in early potato growing in the Huron basin. The later planting, it is stated, enables the grower to escape, in a great measure, the consequence of fungus invasion which is invited by the would be grower for the early market. No attempt at control of early blight, by spraying, has been attempted, although by addition of a fungicide to the spray used for beetles both troubles could be combatted simultaneously.

In the mention of these matters no criticism is intentional. The Huron potato growers, by their present policy, are succeeding in evading the common perplexities of potato farmers in many other sections of the state and are securing profitable crops of good, solid, late keeping potatoes which bring them excellent returns for their labor. But if these returns can be still further increased in any degree by suggestion of different plans to be adopted in

certain cases, or when, as is quite possible, these same growers may be confronted with the difficulties common to growers in other parts of the state, the good intentions of the writer shall have borne the desired fruit.

The main crop, in this section, is planted about the 15th of June. This late planting is supposed to be practically immune from the attacks of beetles and generally secure from danger of late blight. No spraying whatever is calculated to be done in bringing to perfection this late planting. Even the leading potato farmers have not yet considered the purchase of spraying machinery justifiable—though there has, at times, been some loss from late blight. The present season, however, was, in August, still supporting the non-spraying grower in his argument that spraying is not necessary. Great areas of late planted potatoes were the living pictures of health and thrift—the vines covering the ground at the date of the visit. Not a beetle nor a blighted leaf were in sight.

It is evident, we will freely admit, that a field of perfectly healthy and insect-free potato vines cannot be much improved by spraying; but the time must surely come when great loss shall be suffered through over confidence in the "special immunity" of this so far favored section to the obstacles encountered in potato production by growers in various other districts of the state.

The splendid size, uniformity and smoothness of the potatoes grown in the Huron valley sand, insure a ready market at top prices among buyers, while excellent shipping facilities render this section within close touch of the markets of Cleveland, Toledo, Chicago and other large cities.

Notwithstanding the present-day success in the growing industry of potato farming in the Huron valley, there are yet better things in store for the wide-awake growers in this section. As before intimated, losses may have to be sustained, however, before certain means of improvement and insurance of success will be accorded general recognition. In addition to a change of attitude toward spraying for insects and fungi, which must surely come in the future, there will naturally develop an interest in the improvement of seed stock and in varieties of potatoes, which is now but little in evidence. The demand of the day, in this section, is a potato that is round and white. The type represented by Sir Walter Raleigh, Rural New Yorker and Carman No. 3 is the type most liked and generally grown. It seems to matter little in this section which of these three varieties is the stock in hand. Consequently there is a general mixture of these varieties in the same stock. It is stated

too, upon good authority, that an eastern seed firm has offered a slight advance over the market price for this generally composite stock of the Huron valley potatoes, which no doubt would be re-shipped to planters as pure seed stock of either Carman, Rural or Sir Walter Raleigh. This failure to recognize a distinction between varieties of the same type can only result in ultimate embarrassment and a loss to both grower and dealer.

The growing of high-class seed potatoes, upon the other hand, promises a lucrative field for the Huron valley grower. His soil conditions produce tubers of beautiful form and fair skin. The introduction of our excellent newer varieties in this section, or of seed of undoubted purity in the older sorts, together with careful seed selection and improvement would, without doubt, increase the average yield per acre very materially. Arrangements are being made which will present to the potato growers of this valley an opportunity to observe and study many of our excellent and promising newer varieties as well as the standard kinds on their own character of soil and under their particular conditions.

So far as the writer is able to judge, there is not a section in Ohio which is more excellently adapted to potato growing than the one here described; and no reasonable effort should be spared either by the grower so favorably situated nor by those interested and engaged in experimental and investigational work, to bring about a system of cooperation which will tend to develop the possibilities of this unique river basin of a county which produced over 333,300 bushels of potatoes in 1907.

A POTATO GROWERS' MEETING

A visit was made by the writer to the valley of the Sandusky river where potato growing, as a business is attaining quite a degree of importance. It was arranged that the potato growers, farmers, horticulturists and all who were interested in the tilling of the soil, should, under the auspices of the Ohio State Horticultural Society, be invited to join in this visit of inspection. It was anticipated that the topographical and physical conditions which so favor potato culture in this part of the state, would be interestedly observed by the visitors. Moreover, it was deemed of consequence that there should be afforded to the public a comprehensive demonstration and exhibit of those features of potato growing that are at present the subjects of study by scientists as well as leading plant breeders and practical growers everywhere.

These object-lessons covered the fields of potato varieties, variety testing, potato seed selection and improvement, soil fertilization experiments in potato culture and modern methods and equipment for harvesting the potato crop.

The meeting was held near Tiffin, Seneca county. It was an interested, enthusiastic convention of Ohio's tillers of the soil; these including not a few persons from the cities of Tiffin, Fremont, Cleveland and Toledo. Fully five hundred people were present. The proprietor at whose farm the meeting was held is pursuing the lines of corn and potato breeding and experiments in fertilization of these crops, as well as the growing of alfalfa. There were on exhibition at this meeting an extensive collection of "hill-row" products of potatoes from hill selection work; also the various products from different quantities and combinations of fertilizers. The different lots were all shown in crates with explanatory labels.



Fig. 17. Potato digging demonstration at Tiffin, Ohio.

An especially attractive feature was a field demonstration with different potato diggers; this interesting exhibit was given by various manufacturing firms which build potato digging machinery. Five firms were represented in this demonstration which was not in any sense of the word, a contest. No premiums were offered nor was any committee nor individual appointed to determine which of the machines did best work. All worked well under the favorable soil conditions existing at that time, and the great company of visitors which followed the diggers to and fro across the broad potato field, was allowed to draw its own conclusions.

A program had been prepared and was rendered dealing with varieties of potatoes which had been tested on this farm (some 20 varieties), with potato seed selection and improvement and with the culture of alfalfa. The visiting potato growers and farmers

took an active part in the discussion of the subjects presented, and many points were brought out that will prove helpful in the future work of growers. The farm at which this meeting was held is located, as before stated, in the valley of the Sandusky river which flows north through Wyandot, Seneca and Sandusky counties. Soil conditions in this part of the valley are not dissimilar to those existing in the lower valley of the Huron river, some 30 miles north-east, which will be found quite fully described in a preceding chapter.

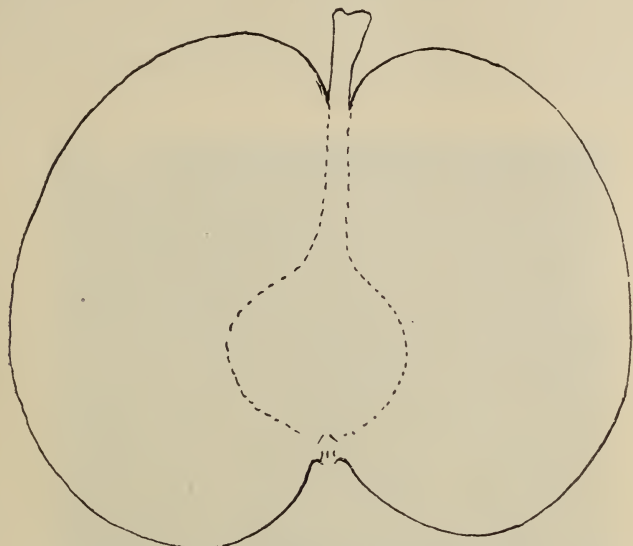


Fig. 18. An excellent type of Sheldon pear

A TYPICAL ORCHARD PROBLEM

During the Ohio State Fair of 1908 a resident of Licking county, left specimens of pears at the Experiment Station's exhibit, for identification. The pears were said to have been grown upon a tree which came up, as a sprout, from the stump of an old tree long dead and gone. As the specimens were of peculiar and distinct "apple shape" and not ripe enough to judge as to their quality at that time, the matter was referred by Prof. W. J. Green, Horticulturist, to the writer, with instructions to visit the grower and endeavor to determine whether the tree were an offshoot from the original variety or from the unknown, seedling root.

Accordingly the designated place was visited a few days later. A careful examination was made of the vigorous, upright, young tree which was found to be five or six inches in diameter of trunk at one foot above the ground, and perhaps sixteen feet in height.

It was difficult to determine whether it sprang from above or below the point at which the original union between bud and stock had been effected, as the stump of the original tree was almost completely rotted away. A comparison of twig growths of the bearing tree with younger and very thorny shoots emanating directly from diverging roots indicated, however, that the bearing tree undoubtedly represented the original variety as had a previous young tree the stump of which is still standing and shown in the photograph of the base of the young tree. The former young tree evidently had never borne, or else its first fruits had failed to attract the attention of the owners, as it clearly had been the victim of a dull axe in the hands of a careless chopper.



Fig. 19. Seedling or original—which?

The owner had, in his enthusiasm over this "new fruit," entertained the thought and hope that it might be a seedling. There seemed not to be sufficient evidence to warrant such a conclusion. If it were an old variety, however it had assumed an exterior guise in which neither Prof. Green nor the writer recognized it. It was almost as truly an apple form, or oblate, as is the Japanese Golden Russet pear. Especially did the larger specimens adhere closely to this form. The lesser fruits approached in some degree a short pyriform or pear shape. In this uncertainty the medium size, typical specimen shown in the accompanying sectional drawing was forwarded to Prof. G. B. Brackett, of the Bureau of Plant Industry, Washington, D. C., who later pronounced the variety a fine type of Sheldon.



Fig. 20. Tree whose base is shown in Fig. 19.

This highest authority in our land should be convincing and conclusive. Otherwise than the peculiar and marked apple shape this pear possesses the characteristics of Sheldon. Its quality, judging from specimens which the grower had saved until the time of my visit, was of that excellence for which the Sheldon is renowned. Yet among the considerable number of plates of Sheldons which the writer has handled in connection with exhibition work in Ohio, not a single plate of this distinctive apple form of Sheldon has been observed. All have approached, in some degree, a short pyriform.

This tree will be kept under observation in the future and specimens of fruit secured to compare with Ohio grown Sheldons from other sections of the state.

In addition to this special pear problem—the springing up of a young tree in an old neglected and well nigh abandoned orchard is representative of a vast number of old orchards and serves in excellent illustration of points which have already been brought out in preceding chapters of this Inspection Report.

TWO NEW SEEDLING APPLES OF MERIT

1. THE LINVILLE

This variety originated as a chance seedling near the village of Linville which is situated on the old National Road in southern Licking county. The tree stands in the edge of a pasture field where, for many years, it was subject to the injuries, mutilations and various “set-backs” incident to such a location. The tree is now quite large, spreading and vigorous.

No special attention was given the tree nor its fruit for a number of years after it attained the bearing age. Insect pests and fungus disease prevalent in many scattered, neglected orchards of that section, were responsible for the annual dropping or gnarling of the fruit. However, late in autumn, six or seven years since, after a series of frosts had stripped the tree of its leaves, quite a number of beautifully colored apples attracted the attention of the owner. Late one evening, as snow was beginning to fall and cold to threaten, he shook the fruit from the tree and carried it to the dwelling cellar. Many specimens were sound and perfect and hard. They kept well and in late winter were found to possess a very pleasant flavor. The attention of the writer was called to the apple at that time. Specimens were secured and shown at the 1902 State Horticultural Meeting at Clyde. It was there reported upon by the Committee on Awards as follows:

"Your committee have to report a seedling apple under the name of "Linville" which appears to be an apple of good quality as a winter fruit—firm and of good flavor and color. Dessert or cooking apple."

The following spring a visit was made to Linville and scions procured. From these a number of root-grafts were made to produce new trees and the balance top-worked upon two trees in the home orchard. As a result the season of 1908 finds several young trees growing vigorously and the larger one of the two trees grafted over entirely to this variety bearing a fair crop of Linvilles despite the fact that a heavy snow came when the tree was just coming into full, heavy bloom, remaining upon the blossoms and branches for 36 hours or more, followed by many days of cloudy, cold, wet weather.

The bearing of these grafts has renewed an interest in this really promising variety which was declared in 1902 by the Pomologist at Washington to resemble Nero—an apple not widely known in the central states.

DESCRIPTION:

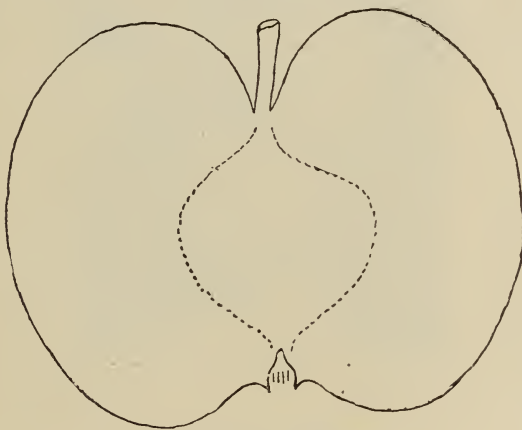


Fig. 21. Linville

Medium in size, roundish-ovate, quite uniform in both size and shape; surface yellow or greenish-yellow almost wholly covered with rich, dark red except about the basin where the lighter under-color is exposed; dots few, light grey or russet on the darker specimens, yellowish on the lighter ones; cavity medium in breadth and depth, usually regular, with russet radiating from within; stem short and strong; basin rather wide and deep, usually smooth but sometimes slightly corrugated; calyx closed or slightly open. Flesh yellowish, firm, crisp, juicy, sub-acid, pleasant, refreshing. Season, December to March.

2. DALE VIEW DESSERT

This variety originated as an accidental seedling in an old chestnut grove on a farm in south-eastern Licking county. Little thought was given either to the tree or fruit other than to gather in the fall, for late autumn and early winter use, such crops as the insects and fungi permitted to develop.

Six years ago the writer visited the farm and discovered the excellence of the quality of this apple from a few specimens which had been overlooked by the tenant at the time of gathering them. A number of the apples were taken home and their culinary qualities tested. They were found to be excellent for sauce, pies, etc., rich and fine in flavor, cooking yellow as gold.

Scions were taken the following spring and a tree in the home orchard grafted over entirely to this fine sort. As with the Linville, these grafts bore in the season of 1908, reacquainting us with the qualities so much admired at the time of discovery.

This variety belongs to the American Golden Russet or Bullock Pippin type, but bears many specimens of a size rarely attained by that delicate little apple. Its size is quite variable, however. The skin is thicker and the russet markings heavier than on the American Golden Russet.

DESCRIPTION:

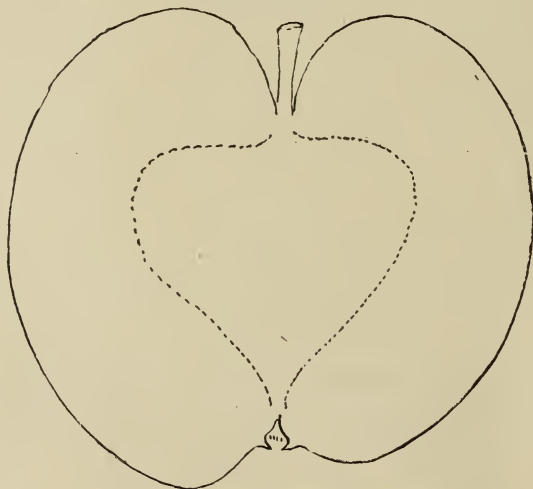


Fig. 22. Dale View Dessert

Because of its superb quality both for eating out of hand and for cooking, the grafted tree of this variety was labelled "Dale View Dessert"—a name which there seems no good reason to change.

Medium or below, in average size, though some specimens attain the diameter and length of two and one-half to two and three-quarters inches; roundish or oblong-conical, one side sometimes a little heavier than the other; surface yellow flecked and patched with russet—the yellow predominating; sunny side often blushed with dull, brownish red in faint dottings and splashes; dots numerous, large, russet; cavity small and regular; stem short and slender; basin very small, regular; calyx small and tightly closed. Flesh yellow, juicy, sub-acid, sprightly, rich and good. Tree a rather slender but vigorous, upright grower.

Desirable for home use, but probably not sufficiently attractive in color for market.

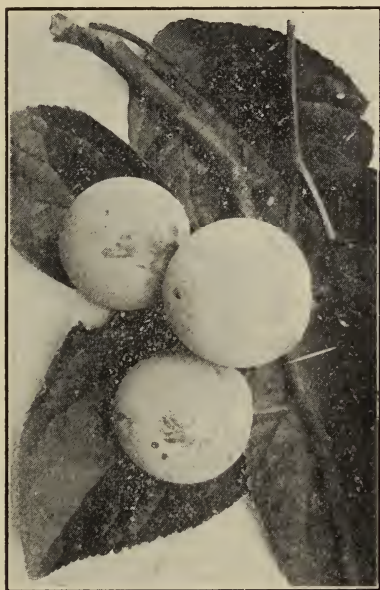


FIG. 23. A New Seedling Plum

TWO NEW SEEDLING PLUMS

1. A seedling plum of most excellent quality was found near Mansfield, Richland county. In fruit it is distinctly of the Reine Claude type, being large, roundish, with a short, thick, strong stem; color, greenish yellow with marblings of a deeper green, over spread with a thin, white bloom. The flesh is very firm though juicy and excellent, separating freely from the small, oval pit. Season September 15. The tree is a strong, spreading, rugged grower and prolific. A very excellent plum for home use. Its color would be somewhat against it for market.

2. There was exhibited at the Ohio State Fair, 1908, a new plum which originated as a seedling on a fruit farm in Ottawa county. In order that its culinary quality might be tested, the writer was presented with a small basket of the fruit at the Fair. As a variety for stewing or canning it would be hard to surpass in all the list of European plums. It is a matter of regret that a photograph cannot here be given; but the many duties of the writer, during the Fair, prevented the picture being secured. The tree was seen during the summer of 1908, but after the fruit had been gathered. It is a strong, vigorous, spreading grower.

Fruit is medium in size, round, blue and covered with a light bloom. Flesh firm, sweet, rich and good. This promising seedling plum has been named "Gill."



Fig. 24. Fae.

THREE NEW SEEDLING STAWBERRIES IN FAIRFIELD COUNTY

In the Spring of 1908, a stawberry grower of Fairfield county, Ohio, sent to the Experiment Station, for trial, three new varieties of strawberries, originating as seedlings on his farm. These were sent under the names of Fae, Mollie and Buster Brown. In June of the same season the originator requested that a representative of the Horticultural Department of the Station visit him and see his new berries fruiting. In response the writer proceeded to his place in June. I am pleased to submit my report as follows:

All varieties of strawberries were, at the time of my visit, suffering from dry weather, though on this place where the soil is of a clayey character conditions were much more satisfactory than where the soil was of a sandy or gravelly nature, as in other sections where observations had been made. A good picking of handsome berries was in progress on the day of my visit. A number of our standard sorts were being harvested. Our friend had been holding on the plants for several days the ripe fruit of his new berries in anticipation of our visit, in order that a fair estimate of their prolificacy might be obtained. Some of the first fruit to ripen, therefore, was in a slightly over-ripe condition, though the percentage that was unfit for market or use at home was very small. Taking up the new varieties in the order of their apparent merit the descriptions are given below:

Fae. Imperfect blossom. Berries large to very large; usually conical, though some specimens are slightly flattened, wedge-shape or divided; color crimson, bright, somewhat glossy, attractive. Flesh pink, firm enough to carry well and of pleasant flavor.

Plants unusually healthy, forming fine, broad, fruiting-rows; very prolific on its home soil. From the fifty foot section of row fruiting, the rate of 2900 quarts per acre, for the single picking, were taken off on the day of the visit. It must not be forgotten, however, that this first picking had been delayed for some days in order that the whole amount of fruit the plants were carrying might be seen. But side by side with the Haverland the Fae is carrying almost as many berries in number and double the size of this well known sort. The trusses are large and support as many as ten berries each in some instances—all well formed this season. The Fae is mid-season in ripening.

This variety was named in honor of the originator's little daughter who takes great interest in her father's business and does the clerical work and much of the crating of berries in the conveniently arranged packing house.

Mollie. Imperfect blossoms. Berries medium to large, conical sometimes a little flattened though usually of uniform shape; bright crimson in color. Flesh is pink, firm and of fair quality.

Plants are quite vigorous, free from disease and moderately prolific. Compared with Nettie the season of Mollie is fully as late at this farm, and it seems superior in vigor of plant; its color is much better and it is fully as firm if not more so.

This variety was named for a young lady who, for several seasons, has been a valued strawberry picker in the originator's plantations.

Buster Brown. Perfect flowered. Berries large to very large, long conical, flattened, furrowed or ridged, sometimes coxcombed; color very dark crimson when fully mature. Flesh rich red throughout, moderately firm and of good quality.



Fig. 25. Mollie

Plants are individually very large and strong in habit, though they show much more leaf-blight or rust than Fae or Mollie; plants send out but few runners, hence it is a rather scant plant maker. Ripens its crop in mid-season.

While named in honor of a very popular character this variety is not so promising as Fae and Mollie, though it is certainly a large and handsome berry. Specimens carried home for photographing were too far gone for securing creditable pictures.

Brief mention of the section of the state in which this grower's farm is situated will not be out of place.

It is situated about 25 miles a little south of east of Columbus and about 10 miles due north of Lancaster. It is the shipping center of an area in which the production of small fruits—especially strawberries—is an industry of considerable importance. Topographically this section is an elevated, comparatively level plain or table land near the head-waters of the south branch of the Licking river, flowing north, and the Hocking river, flowing south.

The farm visited lies about one-half mile north of the village. The soil is, for the most part, a heavy clay loam which seems peculiarly adapted to strawberry production. It is to be presumed

that the conditions observed are rather typical of those prevailing throughout the section surrounding Baltimore for there are several large and successful strawberry growers who are shipping out fruit from that station.

There is apparently much interest taken in the testing of new varieties of strawberries in this neighborhood, though no careful attempts at scientific breeding have been made locally. Under the circumstances this is somewhat surprising; for while the standard sorts seem, with few exceptions, to be succeeding as well or better here than in many other places in the state, there is being conducted a vigorous and, incidentally, expensive search for something of still greater value. I believe that the time is near at hand when some of the more studious growers will elect to take up the work of mating the standard varieties with a view to combining, in separate new varieties, the more valuable and desirable characteristics of two or more old kinds which now succeed best on their particular soils. I am impressed that a bit of definite instruction and a few helpful suggestions along the line of strawberry breeding would in this section, as in many others, be gratefully received and would justify the Horticultural Department of our Station in preparing and issuing, in brief form, just such a treatise. The objection might be urged that this would accelerate the multiplication of an already too extensive list of varieties; but it must be remembered that the unabating interest in and desire to test something new stimulates the multiplication of new sorts in other sections if not at home. If some of this work could be scientifically done individually or in one's home section the desire to test new things would be satisfied and the results would, no doubt, be more gratifying and the expense much less. It is folly to entertain the notion that some other county, some other state or some remote section of the country is more likely to produce new fruits superior to that which may be perfected at home. It is a well known fact—especially to those who have made a study of new varieties of strawberries in Ohio—that new sorts which come to us from the eastern and New England states, or those which come from the far west or southwest, to say nothing of those which come from the south, rarely bestow upon us a variety that becomes standard because of its merits. Among the more excellent of the newer varieties of today those which originated right here in Ohio are succeeding best under Ohio conditions. The same truth will prevail as regards varieties produced or improved in our own county, our own neighborhood or upon our own soil.

The grower visited in Fairfield county, grows seedling strawberries from the seeds of select berries of different varieties. This is certainly a long step in advance of the too common endeavor to find, among accidental seedlings springing up in out of-the-way nooks about the farm, something of value; but the interest and the results should be far more gratifying if the parentage on both sides were a matter of control and record, as in careful isolation of the parent stock and hand pollination of the blossoms.

A SUBJECT OF MODERN INTEREST.

Variation in plants as affecting the improvement or degeneration of varieties.

The basic principle upon which the modern plant breeder rests his reasonable hope of improvement of varieties is the natural variation of plants, not only within the same family or species, but within the same variety. To many of us it is yet a surprising proposition that there are no two things in nature exactly alike. While this is true, we are prepared to believe it only in part. We are ready to admit that there never have yet been two human faces, forms nor dispositions absolutely identical; that there have never been two animals of the same kind bearing physical likeness in every particular, intelligence in the same degree nor dispositions of indistinguishable character. But that plants, even of the same variety, possess individuality and differ one from another we have never, perhaps, been led to consider.

But let us, for the purpose in view in this introduction, hasten to recognize this fundamental truth: there are not only no two trees nor plants of the same variety exactly alike, but no two branches of the same tree, twigs of the same branch nor divisions of the same plant identical in form or character. Even the different buds of the various branches, divisions or twigs possess individuality. These differences are, for the most part, so very slight, so generally imperceptible to the casual observer, that we are warranted in designating a carefully perpetuated variety as pure and practically true to type. However, these variations have no set boundary—no restricted range. Just as an occasional individual person of the same race or family will physically, mentally or morally advance beyond or fall below the average of his people, so do individual trees and plants, or certain branches or buds of individual trees and plants, exhibit points of marked excellence or inferiority to the average of their kind. These lesser variations, in the plant world, we designate “bud variation.”

Through the medium of bud variation, therefore, may a variety be improved or permitted to degenerate. It may be improved by the exercise of proper care in the selection of those occasional individuals exhibiting definite points of excellence and the increase

of these by the usual means of propagation of the species. Upon the other hand, a variety may degenerate through failure to exercise reasonable care in selection for propagation and planting, the superior types, or by rejection of the inferior types as they from time to time appear through bud variation.

In rare instances an individual tree or plant will vary or depart so widely from the common type of the variety to which it belongs—in habit of growth or in the character of its product—as to justify its being regarded as a distinct type or, indeed, a new variety. Such a departure from the parent type, scientifically known as mutation, is commonly and, indeed, appropriately, termed a “bud sport” or “bud freak;” for it must be borne in mind that a tree, branch or twig, or a plant grown from a division of stalk, root or tuber, which exhibits this marked unlikeness to the original form, had its origin in an individual bud.

It is gratifying to note that, in Ohio, these facts relating to the individuality in plants are being widely recognized by both the agricultural and horticultural classes of soil culturists. Substantial progress is being made in certain lines of plant breeding by selection; especially is this true with corn and potatoes.

It is not the purpose to take up the discussion of the various definite lines of plant breeding work in progress in Ohio, at this time; but to stimulate, by a few examples personally noted, a still wider interest in and observation of the variations of plants, by the nature-loving citizens of our state. The man, woman, boy or girl in whom is aroused the disposition to closely and studiously observe that which may be seen all about them—in field, coppice, forest and along the roadsides as well as in orchard and garden, naturally becomes a life member of the rapidly growing nature-student body which is already making its influence felt in the discovery, selection and improvement of those plants which in part feed us, and which beautify our homes.

The following chapter beautifully and fitly illustrates the wonderful phenomena of plant variation to which reference is made in this. Other examples will also be given, which have come under the personal observation of the writer.

A NEW TYPE OF CONCORD GRAPE.

In the autumn of 1906 the writer was apprised of a phenomenon in the form of an unusually large Concord grape which had appeared in the small, home vineyard of a leading market gardener of Richland county. In 1907 an invitation was kindly extended to come and

examine the grape which was fruiting for the third time. The invitation was accepted and the visit proved one of more than ordinary interest from a horticultural standpoint. Mental note of several features of peculiar interest was made, including the distinct and striking type of Concord grape which headed the list and in which there was no disappointment. It was resolved to keep these interesting features under observation for another season or two, or until such time as a report could be made that should prove of general interest and value.



Fig. 26. A striking example of "bud variation." The new type of Concord grape as it appears growing on the parent vine.

In September of 1908, under the provision of the Division of Inspection, a second visit was made. The new type of Concord was still found true to that mysterious and wonderful law which our Creator, through the medium of nature, exercises in the perfecting of new types and forms in the plant world. It was fully up to the standard of its excellence of the preceding season—so persistent, indeed, to its novel characteristics, that it is a pleasure to record in this chapter, its bit of history, well illustrated by photographs from nature.

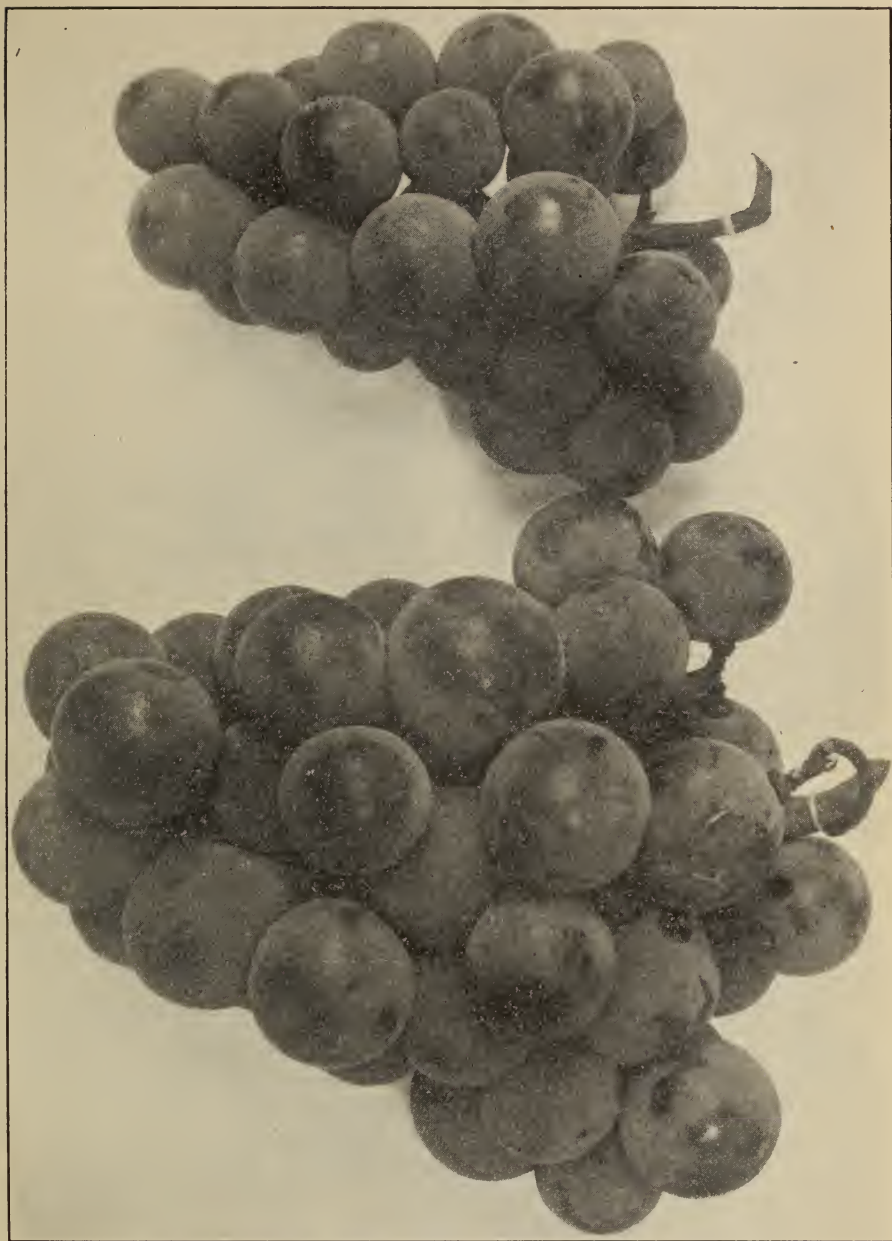


Fig. 27—"Life size" photographs of the common and the new or mammoth type of Concord grape.

The new form is clearly the result of mutation—a “bud sport” or “bud freak.” The vine upon which this new type originated is one of several composing a row of Concord in the small vineyard. This particular vine producing the “sport” divides near the ground into four or five parts which were originally trained upward “fanshape” to the trellis of horizontal wires. From the various divisions the bearing shoots sprang out laterally, each season, such shoots being cut back at each annual pruning to one or two buds. Near the upper extremity of one of these divisions and fully five feet from its base, a certain bud pushed out a shoot which, in appearance, is similar to others springing from the same vine. The following season, however, the single cluster which was borne by this particular new shoot, was so large and handsome and individual berries of the cluster so abnormally large as compared with the common type of fruit borne by the balance of the vine, that it at once attracted attention. The location of the new shoot was noted and the fruit eagerly observed the second season which brought more clusters of equally mammoth berries. The third and fourth seasons, as already stated, have exhibited no features of disappointment.

The photographs show just how the new form of Concord appears on the vine in comparison with the common type borne by other parts of the vine. It was a sight to delight the heart of a nature student.

In conclusion, this new grape is simply a giant Concord. Its color, texture, quality and season of maturity are very similar if not identical. Its value, should the vine upon its own roots prove similar, (which there is no good reason to question) lies chiefly in its superior size and attractiveness. Its parent is so rugged in growth and so generally adaptable to different soils and climatic conditions, that it is reasonable to predict that the offspring would succeed over an equally wide range of country.

No vines of this new grape have yet been propagated, hence no stock is for sale. Nevertheless its owner values this gift from Nature very highly and no small sum would tempt him to part with it. It is to be hoped that a number of new vines may be grown from the new wood, next season; for, should the unexpected happen to the parent vine the new type would perish with it.

TWO ILLUSTRATIONS OF “BUD SPORTING” IN APPLES

1. A well-known fruit grower of Ross county, exhibited at the Ohio State Fair, in 1908, a type of Grimes' Golden apple which presents another excellent illustration of “bud variation.” In this

example the *form* of the fruit alone is affected. Instead of the usually roundish or more frequently slightly flattened or oblate form, this type is decidedly oblong.

A plate of this interesting form of Grimes' Golden was secured, from which a typical specimen was taken, cut and photographed "life size." From this photograph the sectional tracing or drawing was made from the actual outlines of the picture, which is given herewith.

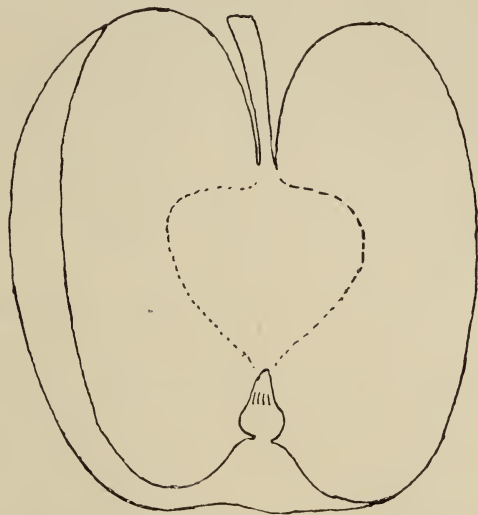


Fig. 28. A distinct type of Grimes' Golden.

This form of Grimes is, of course, no real improvement over the common type, so far as it affects its value. It merely serves to illustrate that different forms of the same variety do exist. The tree upon which this type of Grimes grows is apparently of the ordinary character, but always bears fruit of the oblong shape. The quality of this type is the same as that of the original. It is a clear case of bud variation—the well-grown tree now exhibiting the peculiar characteristics of the single tiny bud from which it was propagated—that single bud among thousands of the same variety which proved so markedly different from its fellows.

2. There was also exhibited, from Lawrence county at one of the Ohio State Horticultural Society's meetings at Columbus, in 1906, a type of Rome Beauty apple that was clearly the product of bud variation. Instead of the characteristic striping of red over the yellow "ground" or "under-color" the type exhibited possessed a smooth, solid, brilliant, rich, dark red color unbroken by stripes or splashings so familiar to those who know the common form. There

was not a single exterior feature aside from the peculiar, smooth, gradually sloping cavity so characteristic in the Rome Beauty, that would enable one to identify this new type. Even the interior of the cavity (usually green or greenish-yellow in the ordinary type of Rome Beauty) was a solid, smooth red in the new type.

It was stated that this Red Rome Beauty is produced upon a single branch of a tree which otherwise bears fruit of the common color and markings. It is evident that this branch had its origin in a single bud just as did the entire tree of Grimes described above.

It is not known by the writer whether this new type of Rome Beauty has been propagated or not. Undoubtedly it would possess extraordinary merit providing the change in type brought with it no physical nor physiological weakness so far as growth and health and fruitfulness are concerned. So far as is known, the chances are about equal for the new form resulting from bud variation, to possess a similar, a higher or a lower degree of vigor. This is a matter to be tested out in each individual case.

A STRIKING LESSON IN PLANT SELECTION

A clear-cut example of the value of selection of plants showing a peculiar resistance to disease, has been studied with renewed interest by the writer in the season of 1908. While urged to relate this experience through the horticultural press, as a contribution to the subject of plant breeding which is of such general interest at this time, it was preferred to include it, in connection with other examples of natural variation of plants, in this horticultural inspection report.

Subsequent to the introduction of the Loudon red raspberry, about a dozen years ago, there were procured 24 plants of that variety from one of the eastern nurseries. They were carefully planted in good soil with a view to rapidly multiply the number of plants for setting. At the time of planting there were noticed a few very inconspicuous "galls" or enlargements on a number of the roots and rootlets. So slight were these that they might easily have been overlooked by the packers at the nursery—even had they been conscientious in their work. The plants grew fairly well, and at the end of the second season after planting there were 300 "sucker plants" available for setting. The plants were dug the following spring and nearly all showed more or less infection by the root- or crown-gall. All were planted, however, as there was not, as yet, that familiarity with that scourge as there was destined to be later in the same season. By midsummer only five plants out of the 300 were living; these were the picture of health and vigor. In the fall these were dug from the different parts of the plot in which they were standing and set together in a short nursery row for the pur-

pose of making another trial of growing plants for a Loudon plantation. After two more seasons had passed, from these fine strong plants, there were dug nearly 500 good plants. No root-gall whatever was found although a close inspection was made of the plants as dug.

The new lot of plants was planted on an excellent piece of ground. Alongside of the Loudons were also set 800 Miller red raspberries which, though unselected for disease resistance up to this time, had proved comparatively free from root-gall. All of the Loudon plants as well as those of the Miller made a fine growth. The Loudons the following year bore a generous crop of the largest and finest red raspberries so far produced in that section. There was no evidence of root-gall or disease of any kind. Two more enormous crops were gathered in 1902 and 1903. The plantation was improving both in cane growth and yield. During the succeeding four years the Loudons continued to produce heavily, much more so than the Millers, and there was not a single break in the rows from the inroads of the dreaded root-gall. In the meantime, however, cultivation having been discontinued, the blue grass was gaining a foothold, and by the spring of 1908 the plantation was so sodded that it was decided to clear off and plow the ground. Not having forgotten the initial lesson in plant selection, it was desired to make close inspection of the old Loudon patch, to determine whether there had been any later development of root-gall. Previous to starting the plow I took a spade and dug up sections of the Loudon rows in all parts of the plot. *Not a single evidence of root-gall was found even on the old stools which were evidently the original or parent plants of the plot.* Old and young plants alike were clean and healthy. This gratifying result led to the inspection of that part of the plot containing the Miller reds. After digging in many places throughout the area in which these were planted *not a single healthy plant could be found. Every plant uprooted showed more or less root-gall.*

As it was late in the spring of 1908, and not much space to spare, only a few of the Loudon plants were saved. This number included both old stools and younger plants. All alike have again grown vigorously and uniformly—as beautiful plants as one could wish to see. A photograph of a typical old plant, as dug from the old patch, is shown herewith.

This has been an experience of unusual interest in the study of disease resistant strains of plants. As all are aware who are at all familiar with varieties of red raspberries, the Loudon, while one of the finest varieties ever introduced, early proved to be discourag-

ingly subject to root-gall. Indeed, so generally recognized became this apparently inherent weakness of the Loudon that it has been gradually dropped from the lists of many—nearly all—plant growers. It is now a difficult matter to obtain plants of this beautiful and superior variety.

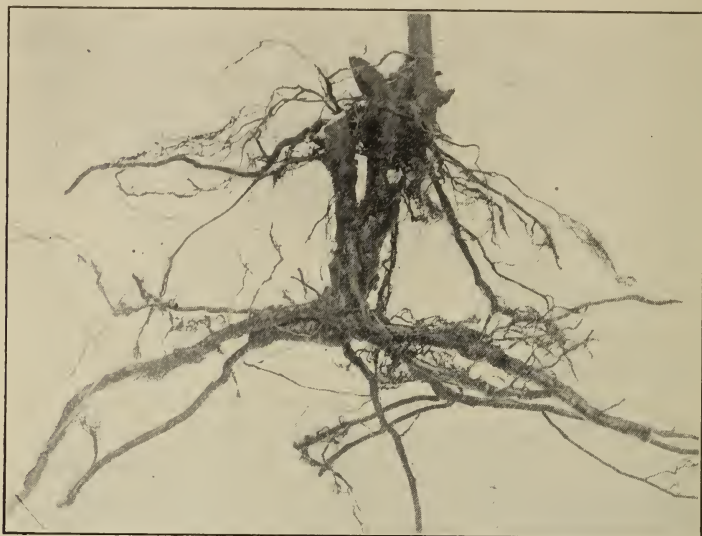


Fig. 29. An old root of disease resistant Loudon.

There are two points which the writer desires to be clearly understood in connection with the submission of this chapter:

First—There are no plants for sale or to spare, of this strain of the Loudon red raspberry improved in disease resistance through elimination of the weaker strains. Should there be plants to spare in the future it will be only after ample time shall have elapsed for any grower who desires a better strain of this variety, to secure plants from other sources and breed up, for himself, by selection of the strong and elimination of the weak, an equally good or better type of Loudon.

Second—It is yet to be proved whether the superiority of a strain obtained by the selection of strong, resistant, individual plants, is permanent, or whether there will be, in future generations, a gradual or partial reversion to the weakness of the ancestry. We should not be content to rest in the assurance that a single selection of plants, no matter how marked the improvement attained thereby may be, is sufficient for all time. Even eliminating the possibility of danger of reversion or degeneration of the improved type obtained, to the recognized weakness of the variety with which we may be dealing, it is only reasonable to assume that there may yet be further improvement of the better strains obtained by the initial selection.

Ohio Agricultural Experiment Station.

CIRCULAR NO. 95.

WOOSTER, OHIO, APRIL 30, 1909.

APPLE SPRAYING IN 1908

By H. A. GOSSARD

It seems desirable to set forth at this time a summary of the results we obtained in our spraying experiments last year. The orchard used for experiment, the property of Mr. John A. Stokes, consisted of 12 acres located near Fremont, Sandusky County. Four acres consisted of trees 24 years old, four acres of trees 20 years old and four acres of trees 12 years old. The three orchards contained 534 trees in all. Besides these were about two acres of scattering trees of various ages, not included in the experiment, but the returns from which are included in the report.



The harvest from two rows of Ben Davis barrelled between the rows.

The trees were planted 33 feet apart each way and, in the older orchards, averaged 30 feet tall with corresponding spread of limbs. The orchard had been regularly sprayed during previous years with a barrel outfit and a short while before our experiments were made was thoroughly sprayed with lime-sulfur wash. The buds were swelling when the lime-sulfur was applied and this treatment probably had a very beneficial effect on scab.



Ben Davis tree sprayed twice.

1. Before bloom with Bordeaux.
2. Heavily with arsenate of lead, 3 lbs. to 50 gallons, soon after bloom fell.

Picked harvest:
 Sound 4469.
 Wormy 8.
 .17 percent wormy.

Total harvest including drops:
 Sound 4833.
 Wormy 15.
 .31 percent wormy.

Wormy apples in hat.

The varieties were chiefly Baldwin and Ben Davis, but Stark, Winesap, Grimes Golden, King, Belmont, Bellflower, Fameuse, Rome Beauty, Walbridge, Pippins and a few others were represented. A few plots of Baldwin and Ben Davis were sprayed with Bordeaux mixture before blooming but most of the orchard received no treatment, except the spring application of lime-sulfur until after the petals fell. As soon as possible after the blossoms fell the entire orchard was given a heavy spraying with arsenate of lead alone, or with arsenate of lead combined with Bordeaux mixture. The Baldwins were several days advanced before spraying commenced but the Ben Davis were exactly right.

The spraying outfit consisted of a 1 1-2 horse-power gasoline engine, a 150 gallon tank and tower, mounted on trucks, and was easily drawn by one strong horse. The bamboo poles were 10 feet long, the one handled by the man on the tower being further

lengthened by a light brass extension about 3 feet long. A "goose-neck" or crook was used at the end of each rod to give a downward angle to the nozzle, thus directing the spray straight into the calyx cups. The man on the tower had a ring cluster of six Spramotor nozzles, while the man on the ground had two Mistry Jr., nozzles made by the Gould Co. The spraying capacity of this combination was about the equivalent of 10 Vermorel nozzles. From 100 to 125 pounds pressure was maintained and, with everything working in perfect order, the 150 gallon tank was emptied in approximately 40 minutes. The youngest orchard was sprayed first, the oldest next and the orchard 20 years old was left until the last. Where arsenate of lead was used alone for the first spraying, a second spraying with Bordeaux or lime-sulfur, or with Bordeaux and arsenate of lead combined, was given as soon as possible after the first application. We managed to work with the wind nearly all the time, and for the first spraying used about 20 gallons of spray per tree for the largest trees, and 10 to 15 gallons for the smallest or 12-year old trees. Some plots received a third spraying with arsenate of lead alone about the 20th of July.



Ben Davis tree sprayed once.

1. Heavily with Bordeaux and arsenate of lead, soon after bloom fell.

Picked harvest:

Sound 4987.

Wormy 54.

1.08 percent wormy.

Total harvest including drops:

Sound 5555.

Wormy 67.

1.2 percent wormy.

Wormy apples in basket on the ground.

Although the young orchard was earliest sprayed and the young fruit was just at the right stage for spraying, more scab developed in this orchard than in the older orchards which were later sprayed. Our Botanist says that it is the usual rule for the fruit from young trees to show more scabbiness than that from old ones. Those plots which received arsenate of lead alone without any fungicide for the first spraying and the check tree developed more scab than the plots which were heavily sprayed with Bordeaux, combined with poison, for the first spraying, but by harvest time very little scab was discernible on Baldwin, Ben Davis, Grimes Golden, or Stark, but the Winesaps, Pippins, Fameuse and a few others were quite scabby. The crop of Winesaps was light, owing to the falling of the young fruit almost as soon as it had set, due to scab disease. All the evidence suggests that in all probability better results would have been obtained by thoroughly spraying these susceptible varieties with Bordeaux before blooming.



Ben Davis tree, sprayed twice.

1. Heavily with arsenate of lead just after bloom.
2. Bordeaux and arsenate of lead two or three weeks after 1. (3-4-3-50 formula.)

Picked harvest:
Sound 5604.
Wormy 55.
.97 percent wormy

Total harvest including drops:
Sound 6399.
Wormy 95.
1.46 percent wormy.

Wormy apples in basket on the ground.

With the exception of a single plot of Ben Davis, no russetting of the fruit could be detected on any of the varieties, no matter how heavily they were sprayed nor when the applications were

made. A single row of Ben Davis sprayed very heavily with Bordeaux and arsenate of lead combined, when the fruit was very small, showed a little russeting, but from a practical standpoint the damage was well-nigh negligible.



Ben Davis tree. Check. Not sprayed.

Picked harvest:
Sound 1240.
Wormy 633.
33.79 percent wormy.

Total harvest including drops:
Sound 1598.
Wormy 1180.
42.5 percent wormy.

Wormy apples in barrel at right.

Owing to the distance of the orchard from headquarters the drops were not picked up in the early part of the season, but all that could be found at harvest time, beneath the trees used for record, were collected and inspected for worms.

The best record obtained was from a Ben Davis tree sprayed with Bordeaux before bloom, and once heavily with arsenate of lead soon after the bloom fell. The following is its record:

Picked harvest.		Total crop including drops		Yield from tree	
Sound	4469.	Sound	4833.	Firsts	5 barrels.
Wormy	4.	Wormy	15.	Seconds	9-10 barrels.
Wormy	.17 percent.	Wormy	.31 percent.	Wormy	hatful.

The Ben Davis trees, if sprayed in good time, were estimated to be less than two percent wormy, including the drops, and the picked harvest was only a fraction of one percent wormy. The

Baldwins averaged one or two percent more wormy than the Ben Davis, owing to the fact that they were further advanced when sprayed. The third orchard of trees, 20 years old, which was sprayed about two weeks after the bloom fell, ran from 3 or 4 percent wormy on some trees, to 33 or 34 percent wormy on others. The only unsprayed check that was reserved yielded 42.5 percent wormy. So far as could be determined, the second and third sprayings with poison had so little effect in reducing the percentage of worminess that they did not pay for the cost of application.



Baldwin tree sprayed three times.
 1. Arsenate of lead just after bloom.
 2. With lime-sulfur, two weeks later.
 3. Arsenate of lead, 3-50, July 22-23.

Picked harvest:
 Sound 4541.
 Wormy 58.
 1.26 percent wormy.

Total harvest including drops:
 Sound 6446.
 Wormy 294.
 4.36 percent wormy

Wormy apples in basket on the ground.

THE RESULT AS A WHOLE

From the entire orchard of Mr. Stokes was gathered 1650 barrels of fruit, which sold at prices ranging from \$3 to \$5 per barrel. A carload of drops weighing 21,600 lbs. was sold in bulk at 65 cents per 100 lbs. From 200 to 300 bushels were sold locally as summer apples at the nearby towns, to neighbors, etc. The total income from the orchard for the season was approximately \$7,400. It is safe to say that from \$5,500 to \$6,000 of this return was net and that the average net return per acre was between \$400 and \$500. From 55 Ben Davis trees, 24 years old, were picked 396 barrels of apples. Since these trees were 33 feet apart each way, 40 trees should be allowed per acre. The average yield per tree

was 7.2 barrels, or an acre, at this rate, yielded 288 barrels. On an average, seven-eighths of these, or 252 barrels, were classed as "firsts" and sold at \$5 per barrel. One-eighth, or 36 barrels, were classed as "seconds" and sold for \$3 per barrel. The value of the drops ran about \$1 per tree. The total receipts, therefore, from this acre of orchard was \$1,408, as closely as can be estimated. After making all allowances for care, spraying, trimming, harvesting, barreling and storing, the net profit exceeded \$1,000 per acre, and this with only ordinary packages and methods of marketing.



Baldwin tree sprayed three times.

1. Before bloom with Bordeaux.
2. Heavily with arsenate of lead after bloom fell.
3. Arsenate of lead, 3-50, July 22-23.

Picked harvest:

Sound 3565.

Wormy 45.

1.25 percent wormy.

Total harvest including drops:

Sound 4272.

Wormy 86.

1.97 percent wormy.

Wormy apples in basket on the ground.

We respectfully call the attention of our fruit growers to these results, and submit that they should carefully consider the possibilities of Ohio fruit production, before deciding that the far western states offer a more inviting or a more remunerative field for their activities.

ACKNOWLEDGEMENTS.

To Mr. J. A. Stokes, and to his son George, who operated the gasoline engine and assisted in all of the spraying, we express our thanks for most intelligent and effective help and cooperation.

About one-half of the work was done under the immediate direction of the writer, who held one of the nozzles, and the rest of it was entrusted to the care of Mr. Goodwin. The July spraying was made in charge of Mr. H. T. Osborn. Part of the negatives for the illustrations were made by Mr. Goodwin.



Loading car with apples to be shipped to Cleveland for putting in cold storage.

Ohio Agricultural Experiment Station

ESSENTIALS OF SUCCESSFUL FIELD EXPERIMENTATION

BY C. E. THORNE

WOOSTER, OHIO, OCTOBER 1, 1909.

CIRCULAR No. 96



Ohio Agricultural Experiment Station

CIRCULAR No. 96.

WOOSTER, OHIO, OCTOBER 1, 1909.



Section C, 5-year rotation, just before harvest.

PREFACE

The increasing interest which the farmers of Ohio are manifesting in field experiments, and the importance of so conducting such experiments as to obtain results which shall be useful and not misleading, are the reasons for the publication of this circular, which is, in the main, a reprint of a syllabus of an illustrated lecture, prepared a few years ago at the request of Prof. John Hamilton, Farmers' Institute Specialist of the Office of Experiment Stations, United States Department of Agriculture, for the use of Farmers' Institute lecturers. It is hoped that its suggestions may be found helpful to those who are entering upon this work.

CHAS. E. THORNE, Director.

ESSENTIALS OF SUCCESSFUL FIELD EXPERIMENTATION

By C. E. THORNE

INTRODUCTION

The experiment station is the distinguishing feature of the new agriculture. It stands for organized research in agriculture; for the concentration of the skill and energy of the entire State on the solution of the unsettled problems of the farm.

The experiment station is created to do things which are impossible to the ordinary farmer. It is furnished with costly equipment and conducted by men trained in the methods of scientific research, who are made free from other cares in order that they may devote their undivided energies to helping the farmer.

But while there are some things which can only be done by the aid of such an equipment as that of the experiment station, there are other things which the station can never do, and the farmer who profits most by the work of the experiment station is he who is himself an experimenter.

It is the province of the experiment station to discover and formulate general principles. The application of these principles must be made by the farmer himself. Even were there an experiment station in every county, there would still be hundreds of farms within each county on which some of the conditions would vary from those of the station, and while no farmer should attempt to duplicate the elaborate work of the experiment station, neither can any farmer afford to blindly accept the conclusions reached at the experiment station without subjecting some of them to the test of further investigation on his own farm.

Were there no other reason for this than the benumbing effect upon the intellect produced by the unthinking acceptance of the dicta of others, as evidenced by the unnumbered centuries during which the sickle remained unchangingly a chief implement of husbandry, this unchangeableness symbolizing a similar monotony in the farmer's intellectual processes, that alone would be abundantly sufficient. The farmer of today must learn to think or he is lost, and nothing is more conducive to exact thinking than scientific experiment.

The experiment station should carry its work far enough to demonstrate clearly the lines which practical application must follow, but after it has reached its uttermost limit there will still be much for the farmer to do.

Many experiments which farmers attempt, however, are either valueless or actually misleading, because of failure to observe some of the essential conditions of successful experimentation, for investigation in agriculture by experiment is a business by itself, entirely distinct from ordinary farming, and many a good farmer will overlook points of vital importance to the success of an experiment until his attention is called to them. It is in the hope of encouraging farmers to experiment more largely and to assist them in making their experimental work more effective that the following suggestions are offered.

SELECTION OF SOIL

A matter of first importance in preparation for field experiment is that the soil shall be as nearly uniform as possible in character. To secure such uniformity the following points should be considered:

GEOLOGICAL HISTORY

It is important, in experiments with fertilizers especially, to know whether a soil is of sedentary, drift, or alluvial origin; that is, whether it has been formed by the natural weathering of the underlying rock; by the action of the great glaciers, which once overspread the northern portion of the United States, grinding up the rocks over which they passed and rearranging their particles in the moraines and sheets of drift which they left behind them as they retreated northward, or by the action of flood waters of rivers and streams, washing down the soil from the higher lands and depositing it in the alluvial flood plains or "bottom lands" of the streams—a force which is in active operation today—as this knowledge may throw considerable light upon different methods of treatment.

A sedentary soil is liable to be more uniform than a drift or alluvium, because in the case of transported soils there is generally a more or less uneven deposit of materials, an excess of gravel and coarse sand appearing in one spot and of silt and finer particles in another. A heavy sheet of drift may sometimes become weathered into practically the same condition as a sedentary soil, while it would seem that some of the great loess deposits would offer especially good conditions to the field experimenter, the loess being the fine-grained, silty soils found in some of the Western States, and whose origin is apparently due to the blowing of the dry surface dust into banks and hillocks, sometimes many feet in depth.

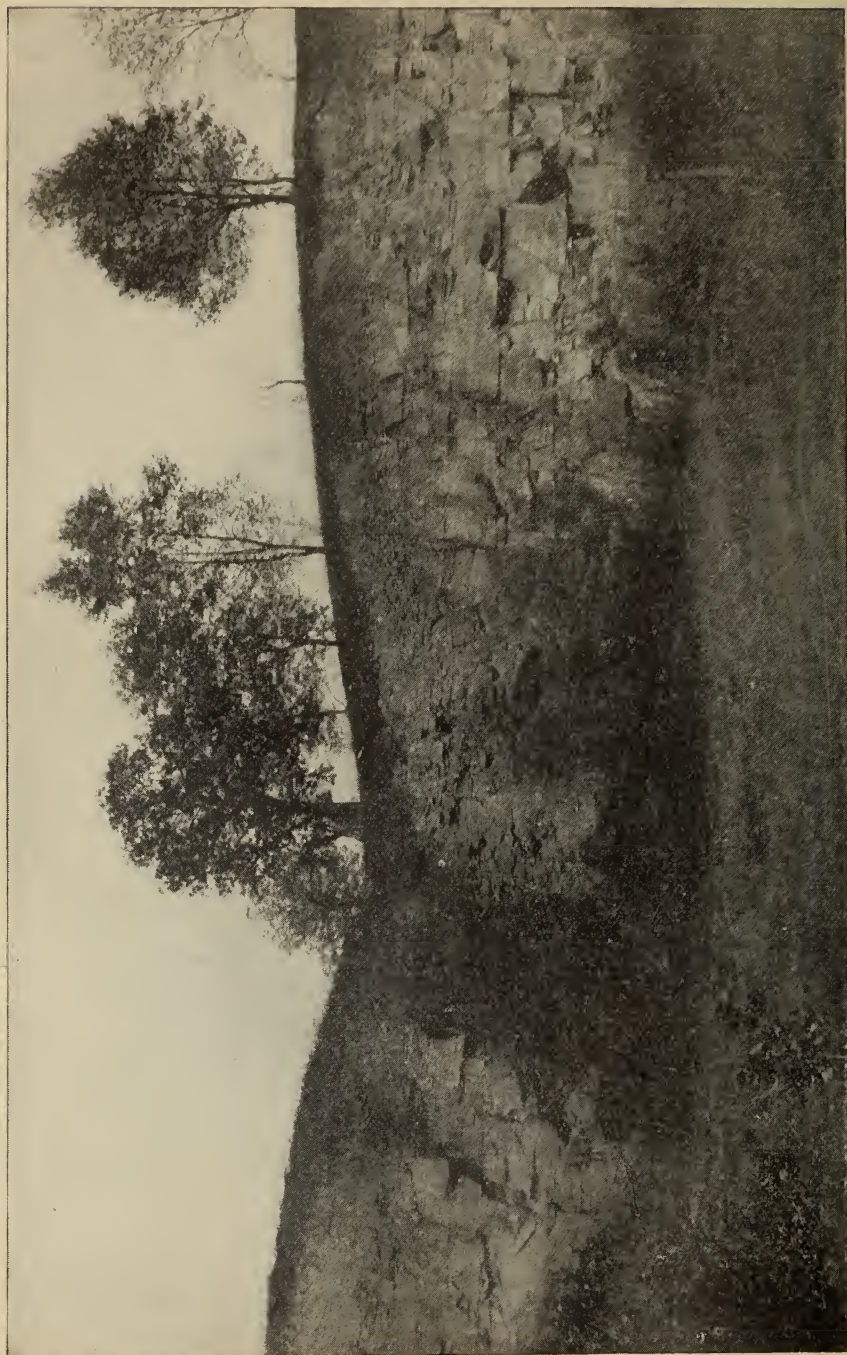


Fig. 1. Face of a stone quarry in a glaciated district, showing the heavy layers at the bottom, gradually breaking up into thinner layers toward the surface and finally ending in a finely broken stratum, over which is spread the thin drift sheet with its contained pebbles and small boulders. In many places in this region this drift sheet is replaced by a thin soil filled with the angular fragments of the underlying rock—such a soil as would be made by a little

PREVIOUS MANAGEMENT

It is also important to know something of the previous management of the soil. The great Rothamsted experiments have shown the persistence of the effect of applications of barnyard manure—the yield from a formerly manured plot remaining more than double that of the unmanured land alongside for thirty years after the manuring had been discontinued. Other illustrations are given to show the effect of leaving fence rows or lanes uncultivated for a period of years and then bringing them into comparison with lands brought under cultivation at an earlier date. Again, a tree which has stood for years after the remainder of the forest has been cleared away, and whose shade has been a resting place for live stock, may cause a considerable variation in the productiveness of the soil which will be manifest long after it shall have been cut away. These points are clearly shown in Figures 2 and 3.



Fig. 2 Showing the growth of corn on an old roadside fencerow, in a region where the discovery has recently been made that it is cheaper to fence cattle in than to fence them out, and consequently the fences are being limited to such as are necessary to inclose permanent pastures, and many miles of road are entirely unfenced.

TOPOGRAPHY

Absolutely level land is seldom adapted to field experiment, for the reason that no land is so flat that it does not have slight inequalities of surface, and on such land the minor depressions receive a larger share of the rainfall by surface drainage from the higher portions, and thus have an advantage in dry seasons when water may be the controlling factor in producing increase of crop, while they may be at a disadvantage in seasons of excessive rainfall. When

the subsoil is porous these depressions may merely be a little more fertile than the higher portions through increased accumulation of humus, but if the subsoil be impervious to water it may give rise to a semiaquatic growth of vegetation which may radically modify the behavior of the soil under cropping. On the other hand, steep hill-sides are not adapted to experiment, because the water from heavy rainfalls in washing over them will cut them into gullies or transport fertilizing materials from plot to plot.

The ideal topography for field experiment is a broad, gentle slope of about 1 to 2 percent, or just enough to permit the surplus water of heavy rains and melting snows to flow off uniformly and completely.

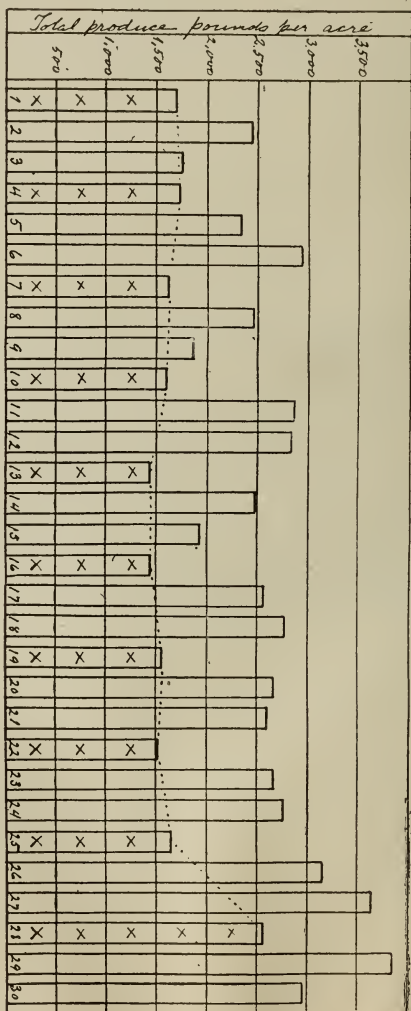


Fig. 3. Diagram showing the yield of the unfertilized plots in an experiment in which corn, oats, wheat, clover and timothy have been grown in a 5-year rotation for ten years. There are thirty plots in the series, and every third plot, beginning with No. 1, has been left continuously unfertilized. The average yield of these plots ranges between 1,400 and 1,750 pounds per acre until No. 28 is reached, when it suddenly mounts to 2600 pounds. This experiment was located in a field which had been in cultivation for fifty years or more, and at the time it was laid out in plots no difference was apparent between the land occupied by Plot 28 and other portions of the field; but it was afterwards learned that this plot and parts of the adjacent plots had been occupied by a lane until some seven years before the test began.

ROTHAMSTED EXPERIMENTS, HOOS FIELD

Barley 51 years in succession on the same land.

Produce, without manure and with farmyard manure.

	Bushels per acre	
	First 20 years, 1852-71	51st season, 1902
Unmanured every year.....	19.9	12 7
Manured every year first 20 years, last 31 years no manure.	48.2	27.5

ARRANGEMENT OF PLOTS

SIZE OF PLOTS

Farmers generally have the idea that experiment plots should be made as large as possible, an idea naturally following their observation of the inequalities of most soils; but the practical difficulty in the way of using large plots is the fact that for a comparative experiment the soil must be as nearly absolutely uniform as possible, and it is extremely difficult to find large areas having sufficient uniformity. In almost all cases it will be found better to use a large number of small plots than a small number of large plots, since by multiplying the plots the variations of the soil can be more evenly distributed. A field of ten acres, for example, in which it is desired to make ten comparisons, will yield results of far greater value if cut into 100 plots containing one-tenth acre each, giving ten plots, distributed over the field, to each particular comparison, than if only ten plots are employed.

The most convenient size of plots for computation is one-tenth acre. When the plots are reduced much below one-tenth acre in size another element enters into the problem, namely, the individuality of the plant. One-tenth acre of corn, as usually planted, will contain nearly a thousand plants, and this number might be grown from a single seed ear; but experiments have shown that ears taken from the same variety and grown on neighboring stalks may vary 50 percent in their produce. Hence, even for plots of one-tenth acre, the greatest care should be taken to secure seed which has been drawn from a considerable number of ears and thoroughly mixed. In the case of wheat or oats a tenth-acre plot may contain from 100,000 to 150,000 plants, the seed of which has probably been obtained from 3,000 to 5,000 heads of grain, representing several hundred separate plants. Hence, we may safely use a smaller plot for the small grains than for corn.

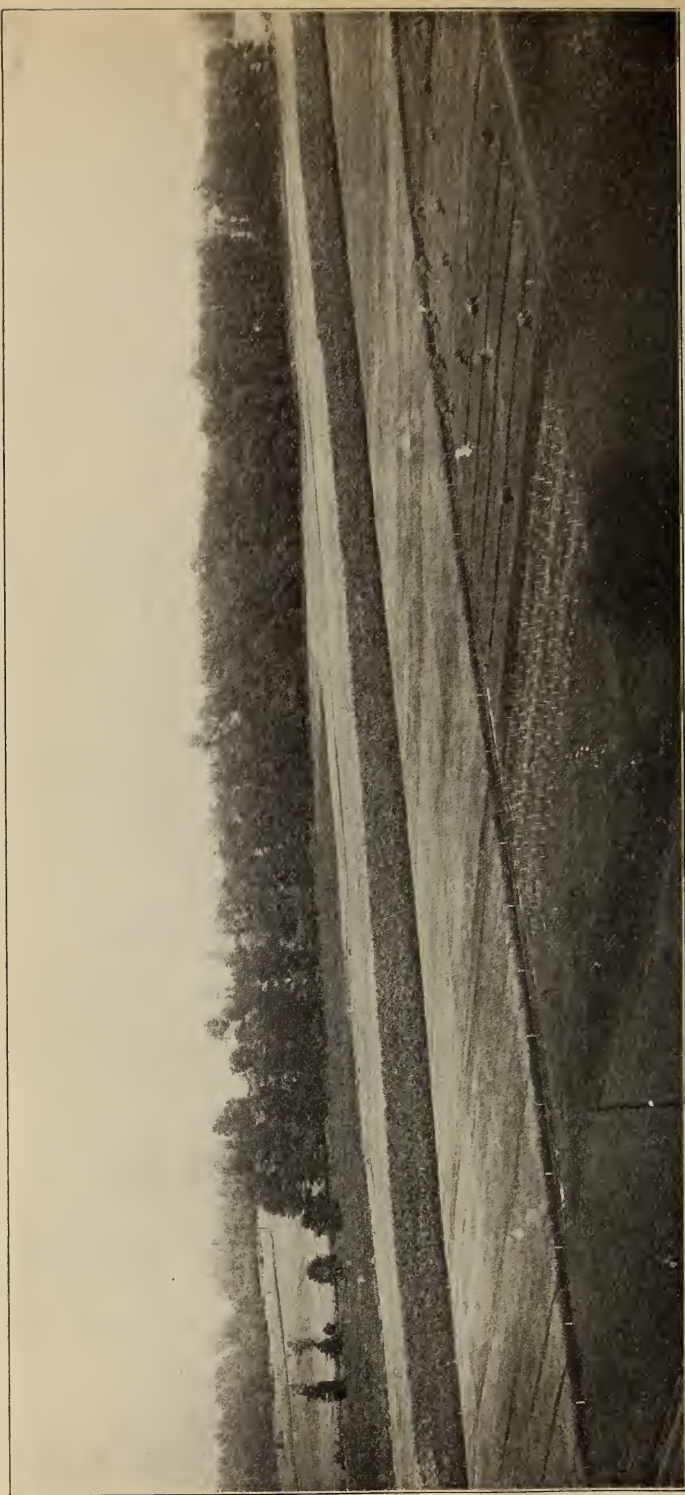


Fig. 4. Part of a field of about sixty acres which is wholly devoted to plot experiments. It slopes gradually toward the north with secondary slopes east and west, which give sufficient fall for the lateral tile drains that are laid between the plots, running east and west and emptying into mains which run north, one on each side of the field.

SHAPE OF PLOTS

It is generally conceded that experiment plots should be long and narrow, both for greater convenience of cultivation and also because this shape permits a better arrangement with respect to irregularities of soil. The minor inequalities of the soil are usually caused by the gradual washing of the surface into small ridges and valleys, which can be so crossed by a long and narrow plot as to cover equal portions of the lower and higher land, whereas this would not be so readily accomplished in square plots. It is well to adapt the width of the plot to that of the machinery in use. A plot 16 feet wide, for example, will contain four rows of corn four feet apart, or five rows of potatoes 38 inches apart. It may be sown with three "throughs" of an 8 hoe, 8-inch drill, and cut in three swaths with a machine having a 5½ or 6-foot cutter bar. The width of the plots should be adjusted to the drainage. When they are more than 16 feet wide it will be necessary on most soils to give each plot a separate drain.

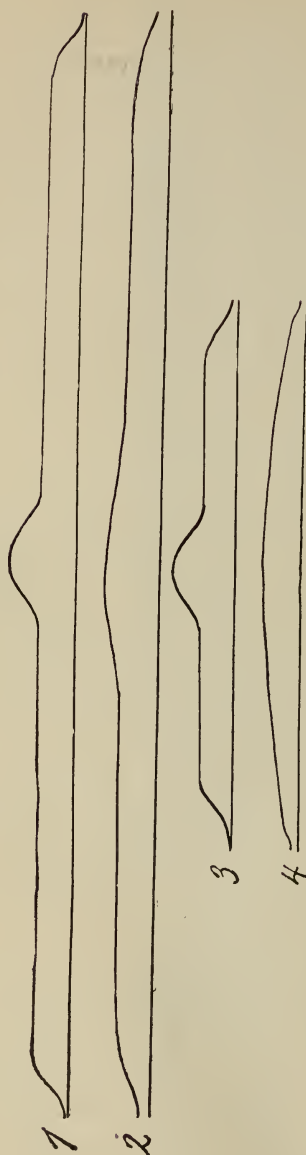
SURFACE DRAINAGE

Whatever the natural topography may be, under most circumstances the uniform disposal of excess of surface water may be facilitated by a slight ridging of the plots, which may be accomplished by plowing the plots separately. To attain this end successfully the plots should be comparatively narrow, in order that the cross harrowing may so distribute the ridge left by the plow as to leave a gradual slope from the middle of the plot to the sides. On wide plots there will always be a flat space left between the ridge and the furrow.

It is not necessary nor advisable to repeat the ridging at every plowing. On the contrary, the effect of ridging will remain apparent for five to ten years, even though subsequent plowings and cultivations be, as they should be whenever practicable, across the plots.

CROSS DRAINAGE

One of the chief objects in separating the plots by dead furrows is to prevent cross drainage of surplus rainfall. Where there are no surface drains such water will, of course, follow the natural slopes of the land, and these are practically never sufficiently regular for the purpose of plot experiment. In variety testing and cultural work this may not always be a matter of great importance, but in fertilizer tests it is essential that the fertilizer applied to each plot be confined to that plot, which can not be the case if the surface water is permitted to flow indiscriminately across the plots.



EFFECT OF RIDGING ON WIDE AND NARROW PLOTS.

Fig. 5. No. 1 shows a plot two rods in width as first plowed, and No. 2 shows the same plot after the harrow has gone over it, partly leveling the ridge or back furrow. Nos. 3 and 4 show a plot one rod wide under similar conditions. It will be observed that in the narrower plot the effect of cross harrowing is to leave a surface having a gradual slope from the crest to the furrow, whereas on the wide plot there will be a flat space left between the two. The practical difference between the two methods of plotting is that the surplus water of heavy rains and melting snows will flow off the narrow plot more uniformly and with less washing and gullying than off the wider one.

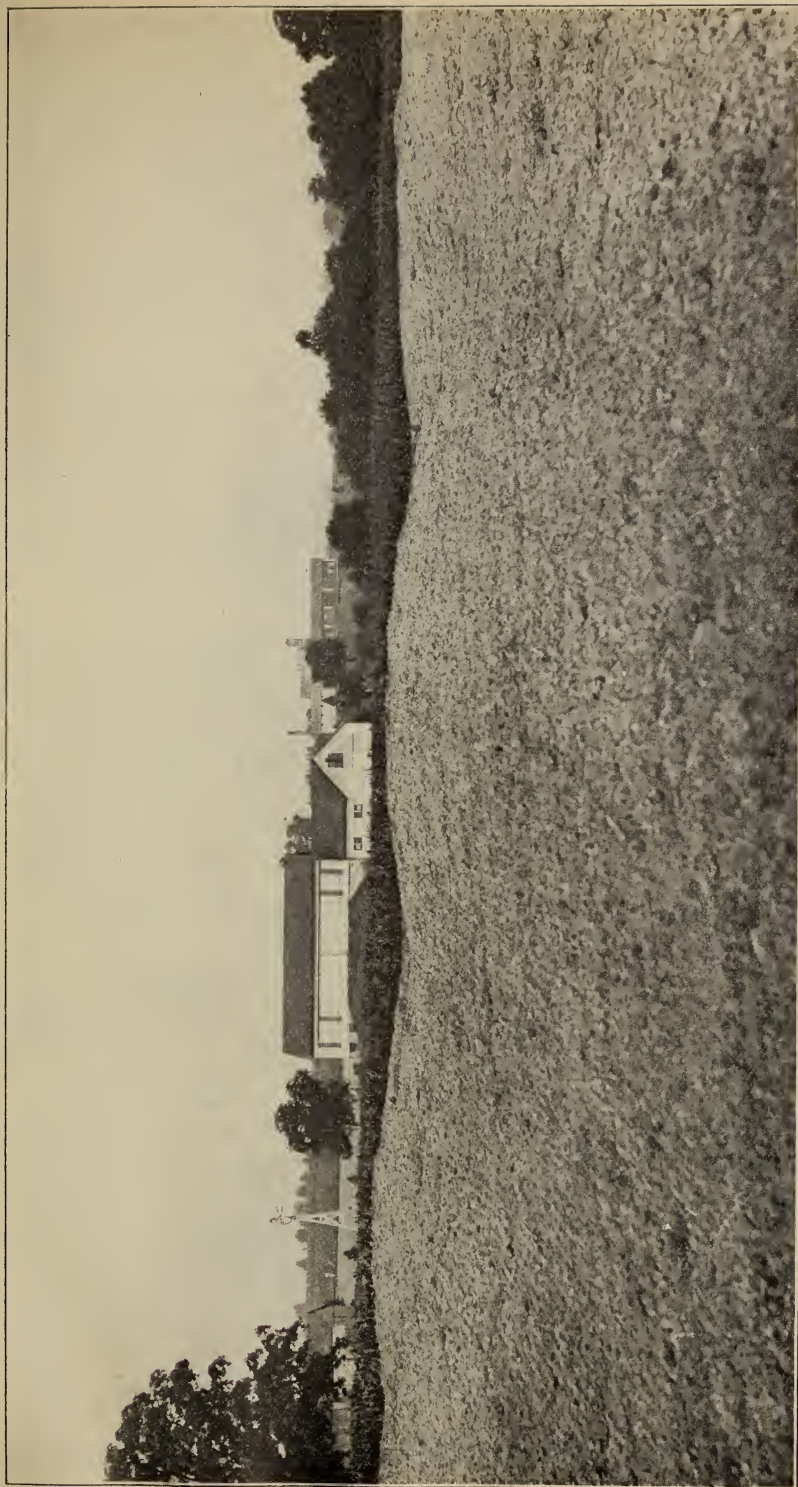


Fig. 6. Contour of plots 18 feet wide from center of furrow as obtained in actual practice. These plots have just been ridged for the third time in twelve years. Future crosswise plowing will materially reduce the height of the ridges.

Even in such work as variety testing, however, it is desirable that the surface water find its way off the plot as quickly as possible. If it stands in minor depressions over the plot it will cause irregularities in yield; if the plots are laid off up and down a slope the water will follow down the drill rows, washing out many plants during the spring thaw, while if the plots are laid off across the slopes there will be cross washing which, in fertilizer comparisons, will vitiate the results. The best arrangement in such work is to so ridge the plots that the surface water will flow from the middle down the sides of the plots into dividing furrows, these being so graded as to carry it away. Some gullying of the furrows is almost unavoidable, but it is better there than within the plot itself.

CROSS FEEDING

Another prime object of a furrow between the plots is to prevent cross feeding—that is, the extension of the roots from an unfertilized plot, for instance, to one that has been fertilized—and this is practically accomplished by the ordinary dead furrow.

UNDERDRAINAGE

Provision for the removal of an excess of soil water is absolutely essential to successful field experiment. Such excess may be naturally removed by stratified rocks lying at shallow depths below the surface, or in rare instances deposits of gravel may be found sufficiently uniform to serve this purpose, but in the vast majority of cases, especially with soils that have been so long in cultivation that a hardpan has been formed, it will be necessary to aid nature by artificial drainage.

In draining for plot experiment the drains should be so located as to give uniform drainage to each plot. When the plots do not exceed a rod in width and the soil is reasonably porous, a single drain may serve two plots, being located under the division space between them, but in the majority of cases it would be better to give each plot its separate drain, located either under the dividing space or under the middle of the plot. The former location is probably the better one where it is not designed to study the composition of the drainage waters, as the surface waters accumulating in the furrow will be more promptly removed if the drain lies immediately beneath the furrow than if it lies under the middle of the plot.

Figure I presents a good illustration of conditions for natural underdrainage. As stated in the description of the cut, there is a gradual transition from the heavy layers of stratified rock, through the lighter layers and broken strata to the thin sheet of soil, which has been formed by the slow weathering of the surface rock, aided

by the action of ancient glaciers. On this soil trees are growing which send their roots through to the rocks below. When the trees are cut away their decaying roots furnish natural drainage channels to the rock seams below, but these channels are gradually obliterated by the scraping of the plow and the trampling of the teams and grazing stock. Eventually the subsurface becomes so compact as to greatly retard the percolation of the surface water, and artificial drainage becomes necessary.

DIVISION SPACES

Division spaces two feet in width have been found sufficient for the separation of the plots, even in fertilizer tests, provided the land is plowed in ridges with the dead furrows falling at the division spaces. Such narrow spaces necessitate special care in seeding in order that the grain may not be sown too far down in the furrow. The dead furrow is rightly named, and in proportion as the seed falls within its influence will the growth of the plant be diminished. When the division space is not more than two feet wide and the planting is accurately done, the resulting produce will probably be a more accurate index of what might be expected under ordinary field culture, under the same treatment, than where the spaces are wider, as in the latter case the outside rows will have a larger area for root extension, before reaching the dead furrow, than in the former.

OLD RIDGES AND DEAD FURROWS

It is of prime importance to so arrange the plots as to avoid the errors arising from old ridges and dead furrows, for either a ridge or a furrow, running lengthwise in a plot, may completely reverse the results of the test. Wherever possible, experiment plots should be laid out across the direction in which the field has previously been plowed.

CHECK PLOTS

A matter of great importance, too often lost sight of in field experiments, is the repetition of check plots. In the most uniform soils there will be some variation in the produce of adjoining plots from season to season. Even were the actual plant food the same, the variations in level which occur on all soils will produce an unequal distribution of moisture, and moisture may often be a more important factor in determining crop yield than plant food. The ideal system of plot experiment would leave every alternate plot as a check. Next to this comes the plan of leaving every third plot as a check, thus having a check plot on one side or the other of every plot under treatment. In fertilizer tests the check plots may be unfertilized or subjected to uniform dressings with a standard fertilizer or manure, depending upon the object of the experiment. In variety tests the check plot should be planted to a standard variety. The importance of repetition of check plots will be further illustrated under the head of calculating increase.



Fig. 7. Two-foot wide dividing space between plots of corn.

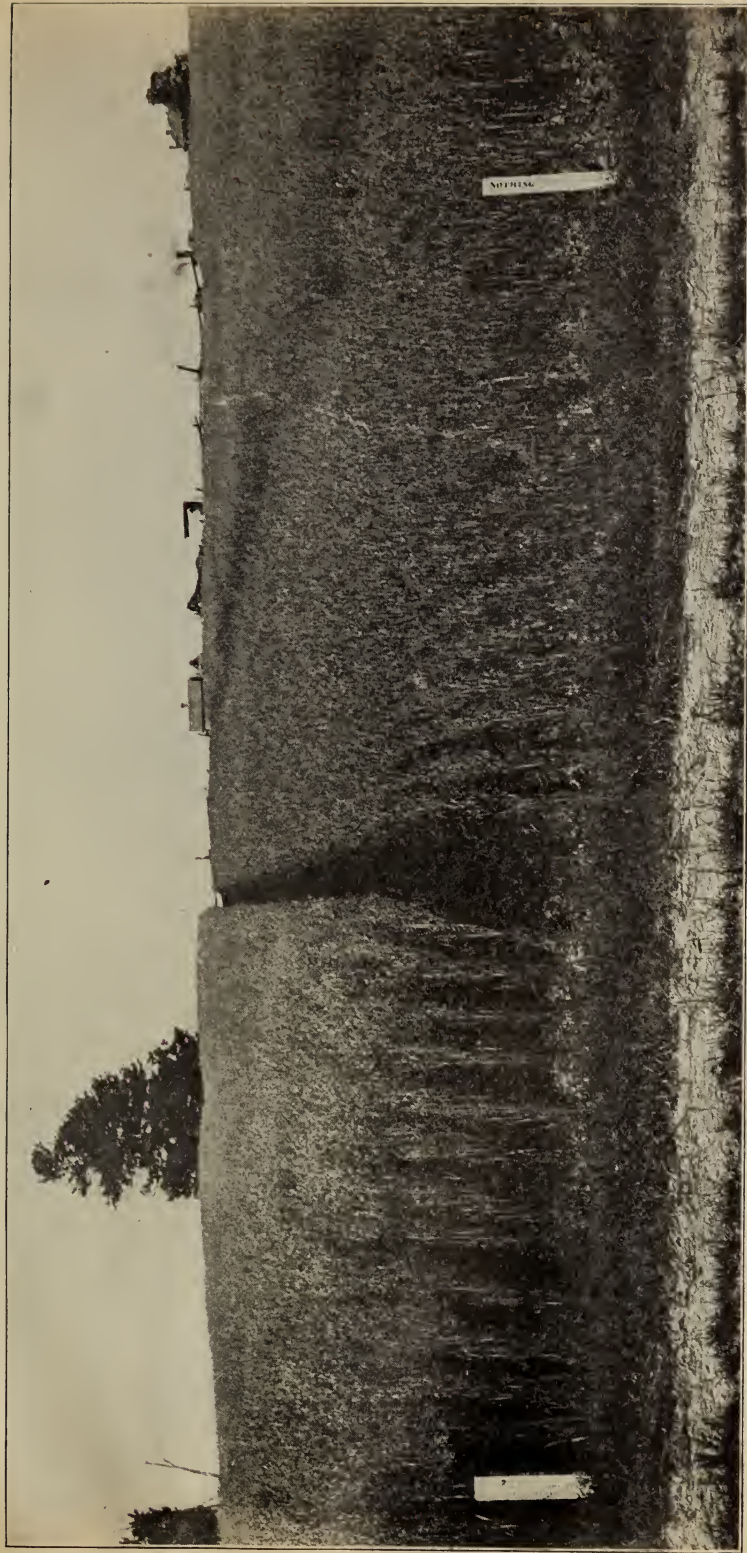


Fig. 8. Two-foot wide dividing space between plots of oats.

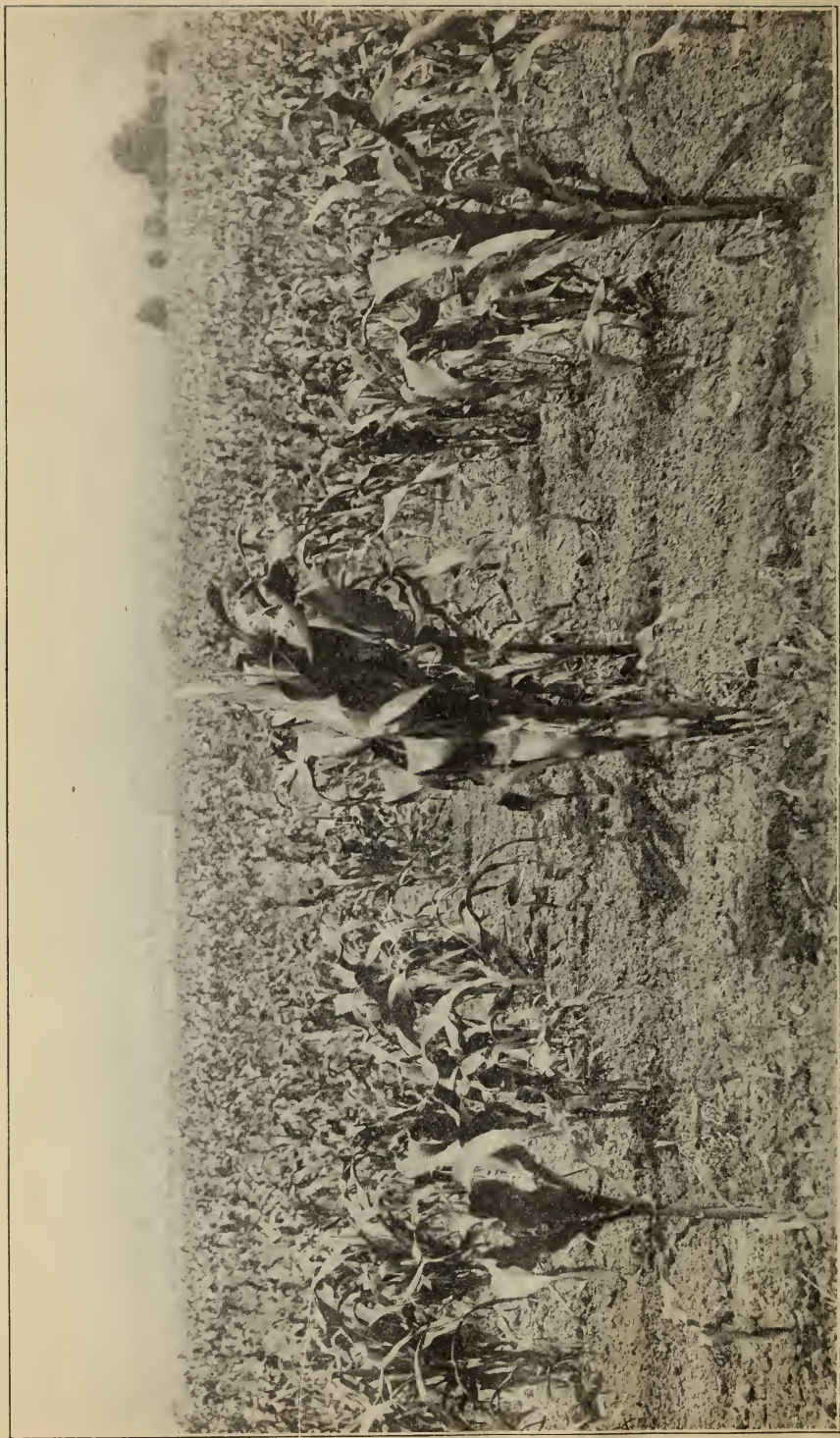


Fig. 9. The middle row of corn in the picture is located on the ridge or back furrow formed by throwing two furrows together. It will be seen that if one plot has such a back furrow and others do not, the apparent results of a comparative test may be very misleading. The effect of an old dead furrow may be equally as fatal to accuracy in results.

PERMANENT BOUNDARIES

A plot of land designed for experiment should be definitely marked with permanent stakes, especially if tests with fertilizers are to be made. A very convenient marking stake for such purposes is a piece of second-hand gas pipe, about two feet long, driven to such a depth that harvesting machinery will pass over it. A block of, say, ten plots may be marked with such stakes, set at the corner of the block, the intervening distances to be measured for each planting.

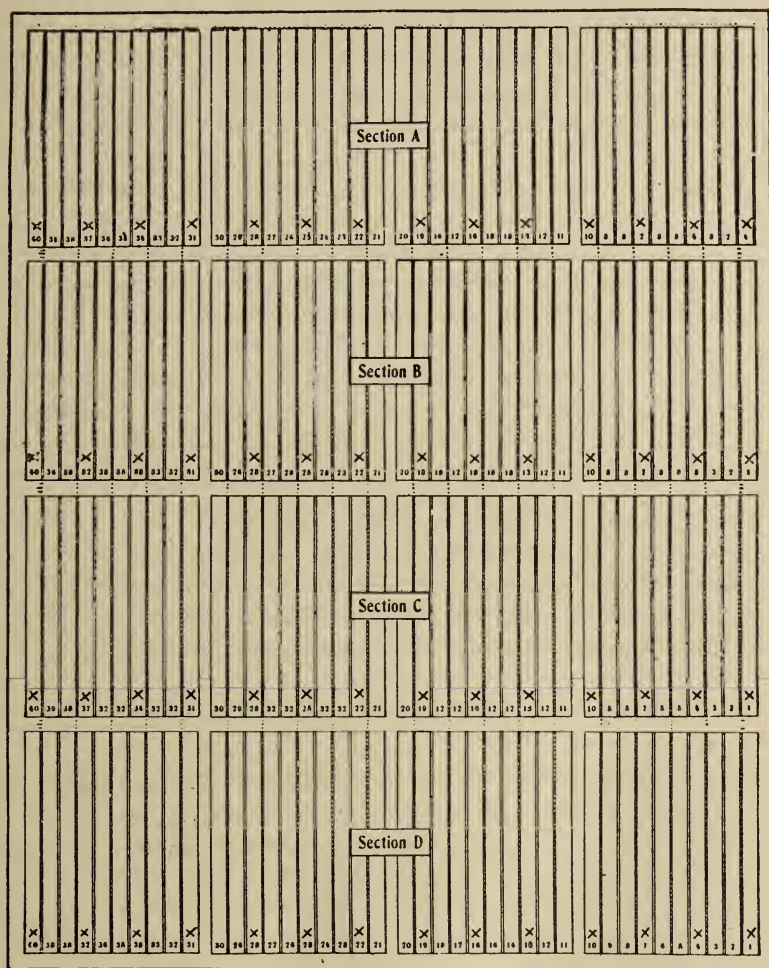


Fig. 10. Four ranges or tiers of plots, 40 plots each, as actually employed in an experiment in which corn, oats, wheat and clover are grown in rotation, each crop being grown each year. The plots marked X are check plots.

HEADLANDS AND ROADWAYS

Ample headlands should be left across the ends of every block of experiment plots. Not only are these headlands needed to prevent the breaking down, in turning while cultivating, of such crops as corn or potatoes, but they are required in the harvesting of the small grains, in order that the machine may be driven around the plots empty, and they are even more urgently needed in plowing, as the trampling of the soil by the team in turning the plow will materially affect the yield of the following crop. These headlands may be made 18 feet wide, but 20 feet is better.

In addition to the headlands there should be roadways at intervals through every large group of plots, to permit the first passage of the machine in harvesting, or the continual passing where it is necessary to cut the grain but one way, and the passage of wagons in hauling manure or grain. An experiment plot should never be used as a roadway, for the reason given above, that the additional trampling and packing by the teams and wheels, even in the driest weather, will so change the physical condition of the soil as to affect the future yield of crops. A convenient arrangement, where the plots are not more than 16 feet wide, is to leave a 12-foot roadway between blocks of eight or ten plots. These roadways may be planted to the same crop as that grown on the plots, the roadway to be cut out and the produce set to one side where it will not be mixed with that of the plots before the harvesting of the plots is begun.

The headlands, however, should be kept in grass, in order that the plots may at all times be accessible. Nothing will add so much to the interest in and value of an experiment as to be able to visit it at any time and to see clearly the contrast between plots. It is not waste, but economy, to give a little land to this purpose.

LABEL STAKES

Every plot should be distinctly marked with a label stake, giving the number of the plot and an indication of its treatment. A very convenient stake for this purpose is a board four inches wide and 30 inches long, sharpened at one end, painted with three coats of white-lead paint, and lettered with price markers or with brush. Such stakes, if taken up and sheltered through the winter, will last ten years or more.

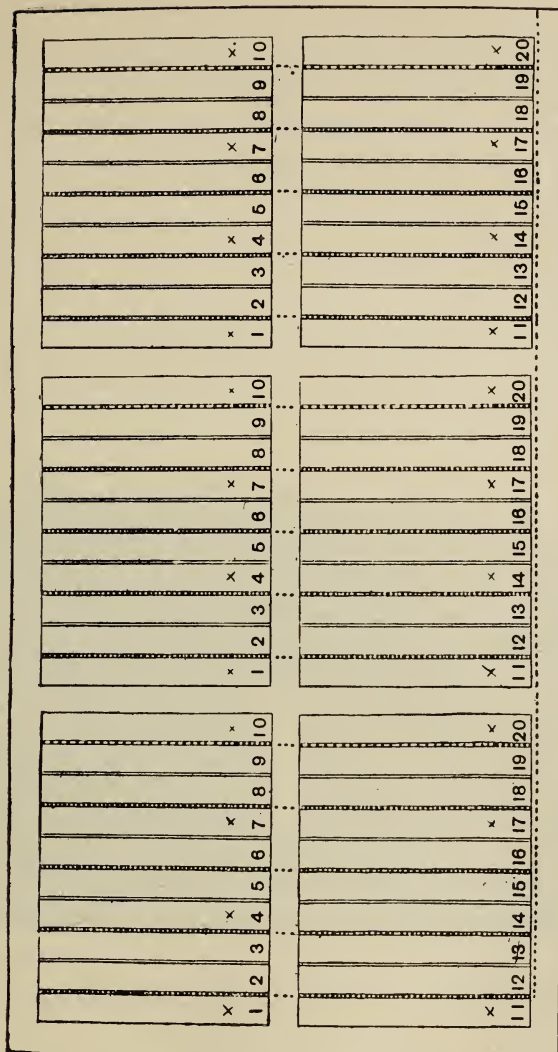


Fig. 11. Six blocks of ten plots each, arranged for a 3-year rotation.

PREPARATION OF LAND FOR CROPS

UNIFORM PLOWING

It is highly important that the plowing and fitting of the land for a comparative experiment be as uniform as possible in every respect. A difference of a few weeks in date of plowing may cause as great a difference in yield of crop as will be produced by difference in fertilizing, and far greater than is usually observed between varieties. For this reason the plowing should, as a rule, be done across the plots, and when it becomes necessary to plow the plots separately, in order to ridge them, the work should be pushed forward as expeditiously as possible. On this account it is well to have the plots arranged in blocks of ten, planning the test so that each block will have its complete series of checks, independently of the others.

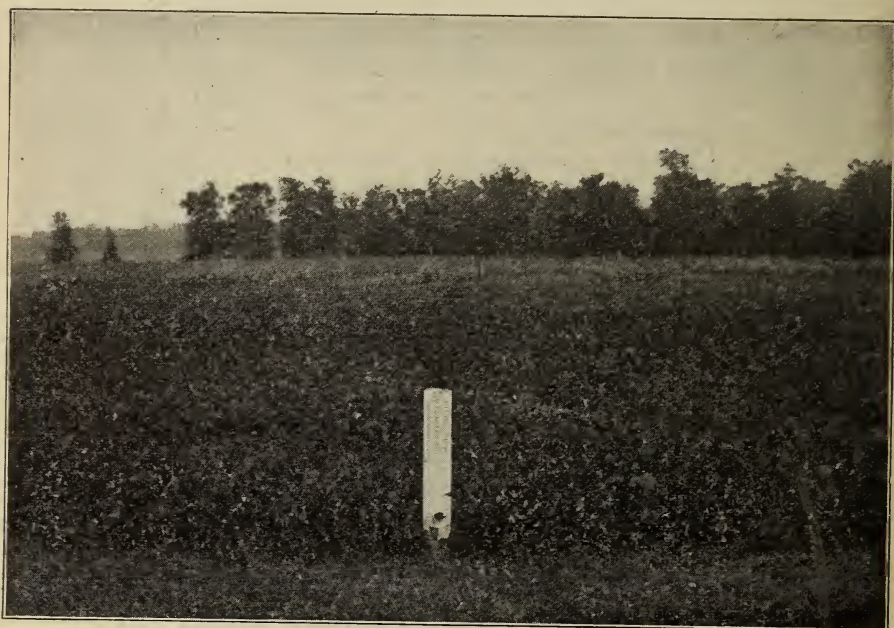


Fig. 12. A convenient label stake four inches wide by 30 inches long, painted white and lettered with a brush. These label stakes are useful but should never be permitted to take the place of a carefully written record or diagram, as stakes may be easily transposed or lost. The stake should be so lettered as to show the number of the plot at which it stands, and also the kind and amounts of fertilizer applied to that plot.

MANURING AND FERTILIZING

Both manures and fertilizers may be distributed by machinery more uniformly and accurately than by hand. In a comparative test of manures or fertilizers it is important that the material be kept entirely on the plot, leaving the dividing spaces entirely untouched; but where the test is one of varieties or methods of culture the

entire surface may be covered. In applying fertilizers it is a good plan to bring the applications intended for the different plots all to the same bulk, by mixing them with dry sand, so that a single setting of the drill may suffice for the entire experiment. Even then it will not always be possible to exactly gauge the material, for mixtures which are largely made up of such salts as nitrate of soda and muriate of potash will pass through the drill less readily than those which contain a larger proportion of sand. It is a good plan to test the drill by sowing an equal bulk of material on a plot not designed for experiment before beginning the actual work. The fertilizer will run more slowly as the drill becomes nearly empty; hence it is well to set the drill so that a little will be left in it after the plot has been gone over, and then turn back over the work until all is out.

Machines are now made for distributing fertilizers and lime broadcast. They are made wider than the ordinary fertilizer drill and are guaranteed to spread even slaked lime satisfactorily. Where such a machine is not available, the manure spreader may be used for lime spreading, first spreading a layer of chaff or similar material in the bottom of the machine and spreading the lime on this. Where small quantities of lime are to be applied—1,000 pounds or less per acre—it will be an advantage to gear the machine so that the apron will travel more slowly than in ordinary work. The best manure spreaders are now fitted with hoods and slow gearing for lime spreading.

MACHINES SHOULD BE ACCURATE

While a good machine will do better work than can be done by hand, there are many machines in use which are not fit for experimental work. There are both corn planters and grain drills which do not distribute the grain uniformly, while there are others which are unsuited to the experimenter's purpose because they are too difficult to clean out, thus greatly increasing the difficulty of making variety tests. In thrashing, this last difficulty is still more conspicuous. The modern thrashing machine is gotten up at a low cost and intended only for rapid work on a large scale, and is altogether unsuited to the separation of different varieties of grain. The older thrashing machines, with the traveling apron, are better adapted to this work than the modern machine. There should be no place for grains to lodge in passing through the machine, but it should be so constructed that every grain entering the cylinder will be promptly carried through the machine and out at the proper place. It is possible to do this, but of course the cost of the machine will be increased.

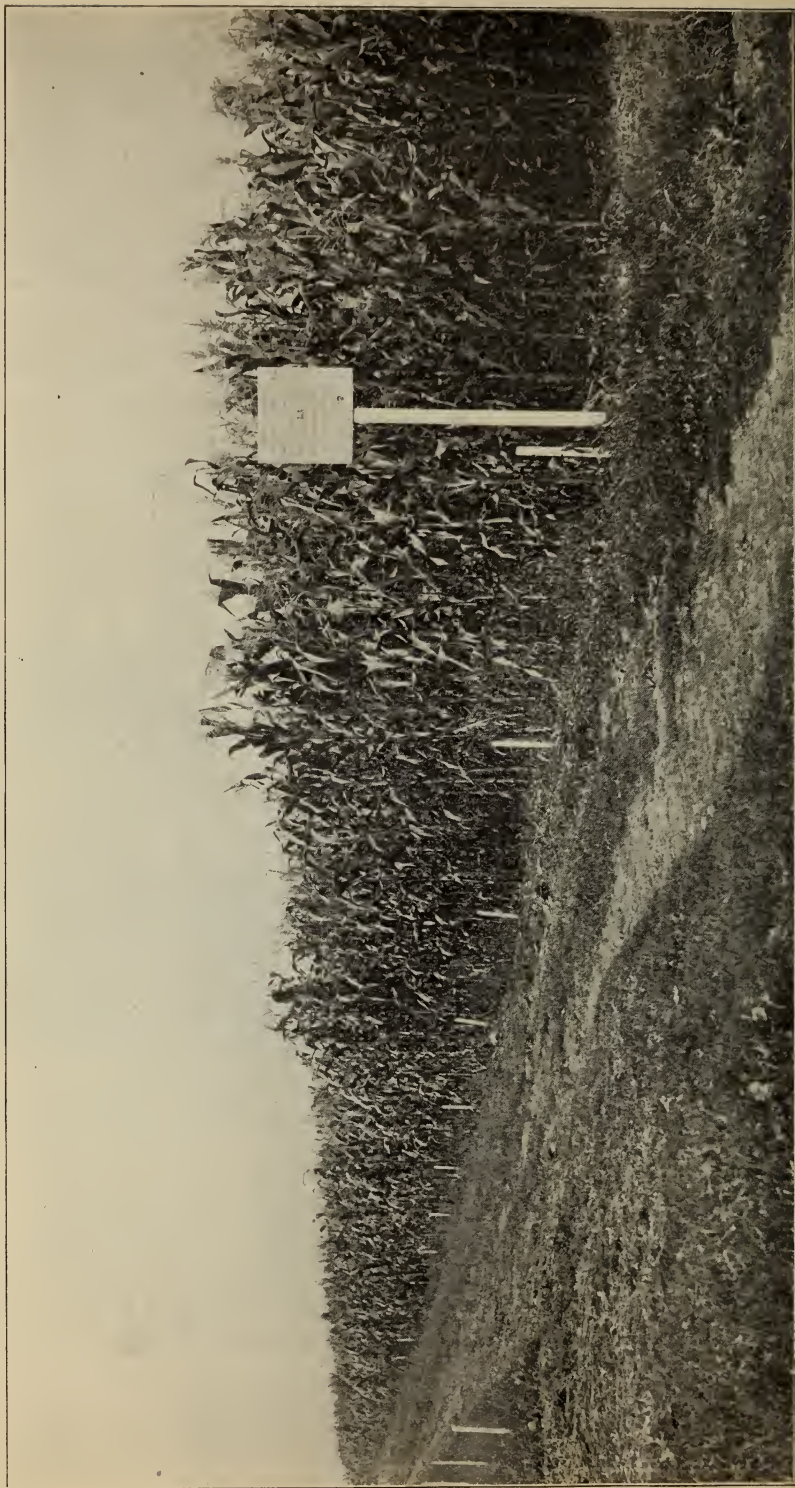


Fig. 13. Showing a sign board for the convenience of visitors. This sign board should show the nature of the experiment by indicating the length of the rotation and the kind of crops grown, etc.

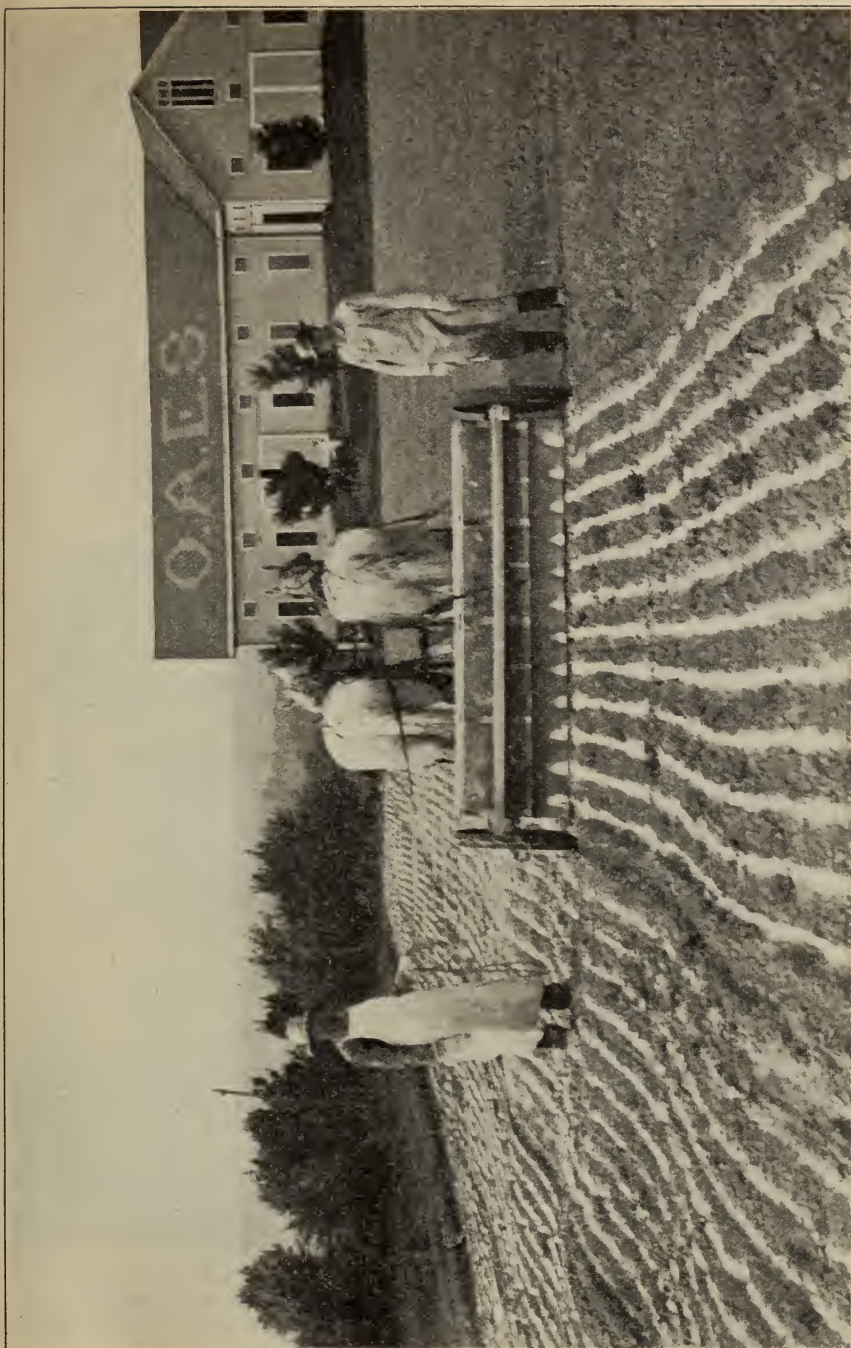


Fig. 14. Distributing lime with a lime spreader. This implement is much to be preferred where lime is used in any considerable quantity.

SELECTION OF SEED

The selection of seed is a very important matter in field experimentation. Defective seed means an imperfect stand, and an imperfect stand means an unreliable experiment, for no method of calculation yet known will correct the inequalities of an irregular stand. Not only should the seed be strong in vitality, but it should be uniform in size, because such uniformity not only is necessary to uniformity in distribution by machinery but also to uniformity in growth of the young plants. For this reason the seed corn should be selected from the middle of the ear, rejecting the butts and tips, and wheat and oats and other small grains should be carefully graded by passing them through a fanning mill and over a sieve, which will take out the small and imperfect grains.

THE ROWS SHOULD BE STRAIGHT

That rows should be straight applies even more forcibly to the small grains than to corn, for a careless driver who allows his rows to run together by so much reduces the yield of the plot, as experiments have shown that where the quantity of seed passes above a certain maximum—and the regular seeding should be near this maximum—then the yield falls off; so that when two rows run together not only do we lose all the produce of one of the rows but part of that of the other.



Fig. 15. Distributing lime with a manure spreader. This is the best substitute for the special lime drill which we have. By spreading litter of some sort over the apron and putting the lime on this, and by using the hood, as shown in the cut, we can get a fairly satisfactory application of the lime, although the work will be found to be much more dusty and tedious than with the special lime spreader.

THE ENTIRE PLOT SHOULD BE PLANTED

In drilling the small grains most drills will travel a short distance before the seed reaches the ground. If the drill is started at the exact end of the plot, therefore, there will be a short space unsown. To guard against this the drilling should extend beyond the ends of the plots, the excess being cut away before the plot itself is harvested. The best way to accomplish this is to stretch a line between the stakes marking the corners of a block of plots, and with a hoe cut out a narrow strip under the line. The nose of a machine may then be made to follow this strip, thus quickly cutting away the excess, which of course must be kept out of reach of those who haul in the grain, if the trimming has been left until harvest time, but the better way is to trim the plot ends while the crop is still green, making hay of the produce. Not only will this method remove all danger of mixing the results, but it will add to the satisfaction of watching the maturing of the different plots.

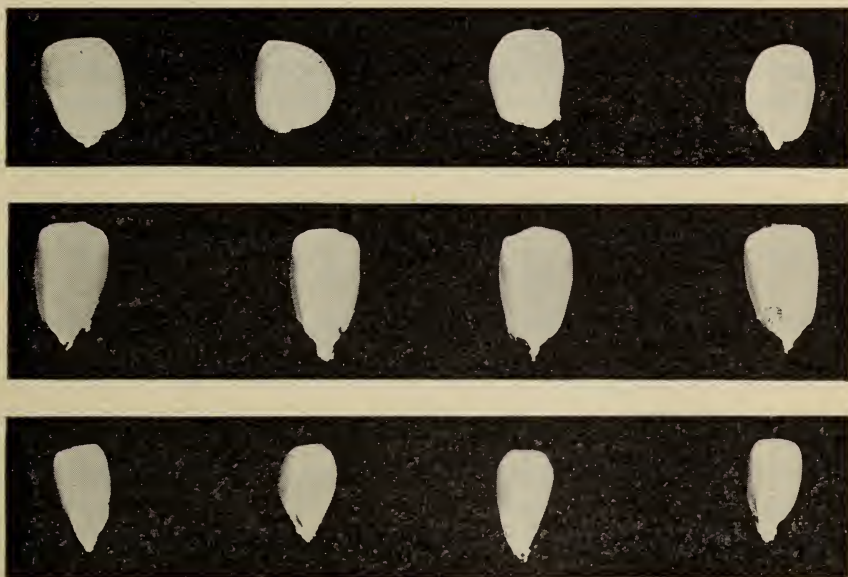


Fig. 16. Four grains of corn each from butt, middle and tip of the same ear, showing difference in size.

PLANTING AND CULTIVATION

MACHINE WORK PREFERABLE

Wherever possible machinery should be used in planting and cultivating. There is no longer any question as to the superiority of drilling the small grains over sowing them broadcast, and the

same principles apply to the corn planter, at least, if not to the potato planter. Certainly they do to the tobacco planter. The seed grain is deposited more uniformly by the drill or planter, whether as to quantity of seed, depth of planting, or uniformity of covering, than can be done by hand. Even the hand corn planter is better than dropping the seed by hand and covering with the hoe, while a man and two boys will set tobacco or cabbage plants not only very much more rapidly but also much better with the machine on which they all ride, carrying with them a barrel of water which automatically deposits a cupful at uniform distances in the row, the boys alternately placing a plant in the freshly opened furrow just as the water reaches it, while the machine closes the furrow and presses the earth around the plant.

In cultivating, and especially in harvesting, machinery is essential to rapid work. An experiment with cereals is incomplete unless the proportion of straw or stover to grain is determined, and it is practically impossible to secure uniformity of stubble, either of small grains or corn, by hand cutting.

In thrashing the small grains no one would now think of using the flail where it was desired to make an accurate determination of the separate product of straw and grain. With corn, however, thrashing machinery has not yet reached a stage at which it can successfully compete with hand husking.

HARVESTING

CUTTING GRASS PLOTS

In experiments with crops grown in rotation the grass and clover crops usually occupy the dividing spaces, as well as the plots proper. A convenient and fairly accurate method of harvesting such plots is to drive the machine to stakes, so set that the point of the machine will just reach the outside of the plot. A careful driver with a steady team can thus cut a swath as straight as though a line had been stretched. After the outsides are thus cut, the cutting out of the middle is a simple matter. The dividing spaces should be left uncut until the hay has been taken up from the plots.

HARVESTING SMALL GRAINS

When plots of small grain are arranged in blocks, as has been above recommended, the roadways are first cut out, the ends of the plots straightened, if this has not been previously done, after which, if the grain be not lodged, the machine may cut up one side of the block and down the other, running empty across the ends, of course, but a man should follow the machine to remove the residue that may be left on it as it leaves the plot and to see that each sheaf is finally left on the plot to which it belongs.

HARVESTING CORN

The corn harvester will no doubt come into general use because of its great saving in labor and because of its uniform stubbles, but in experiment work it is indispensable that a gleaner should closely follow the harvester in order to pick up dropped stalks and ears which may be broken off and keep them on their proper plots.

HARVESTING POTATOES

Potatoes may be harvested with the potato digger with a fair degree of accuracy by harrowing the ground after all the potatoes thrown out by the digger have been taken care of, and picking up those exposed by the harrow. The advantage of machine over hand work, however, is much less decided in handling the potato crop, whether in planting or harvesting, than in case of grain and grass crops.

WEIGHING

THE WAGON AND STOCK SCALE

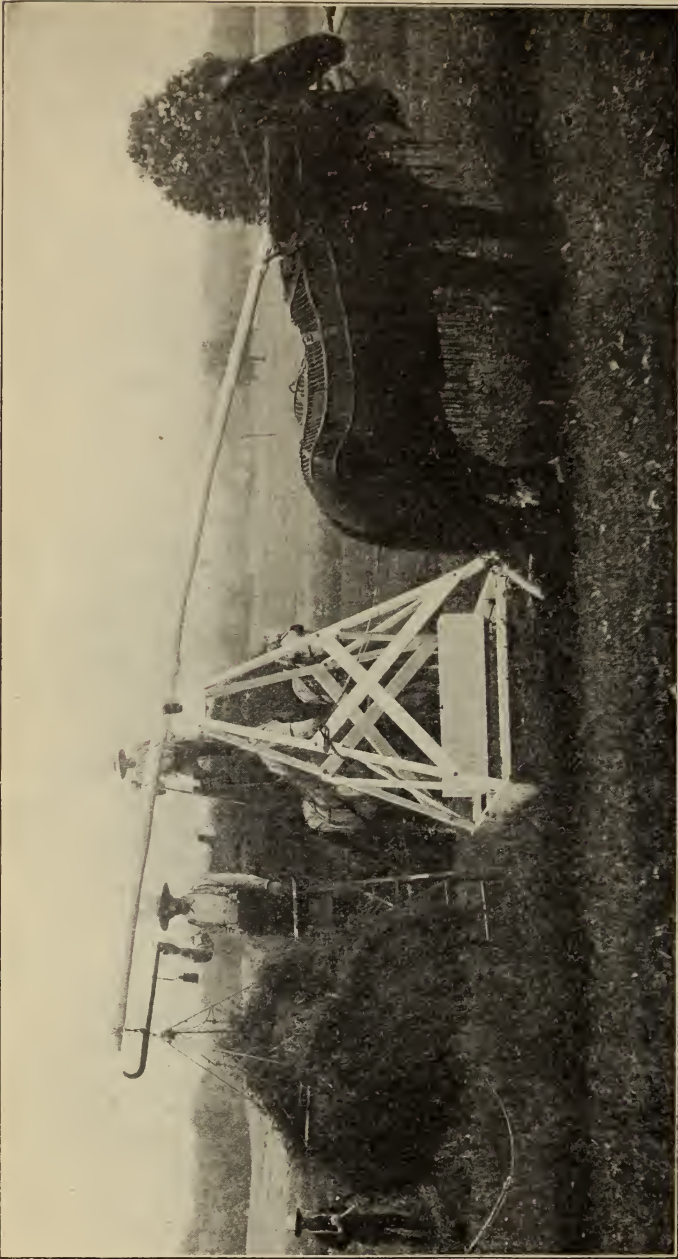
The wagon and stock scale of about four tons capacity is found on many farms and is indispensable where feeding experiments are being made. With such a scale the relative weights of grain and straw may be ascertained with a fair degree of accuracy by weighing the grain in the straw on the wagon as it is being drawn to the thrasher and again weighing the grain as it comes from the machine, the weight of the straw being found by the difference.

Several plots may be carried at once by separating them with sheets, reweighing, of course, after each plot is unloaded. In the same manner several plots of hay may be brought in at once, especially if the hay sling be used for unloading.

THE PORTABLE DERRICK SCALE

The portable derrick scale is an implement much less expensive than the wagon scale and at the same time more accurate. It consists of a derrick, similar in construction to the oil or gas well derrick, but only eight feet high and correspondingly light in construction, and mounted on a pair of sled runners.

This derrick scale is especially useful in weighing the corn crop where it is husked in the field, as it may follow the huskers, weighing the stover before it is reshocked, and by means of a light platform or large basket, substituted for the hay sling, weighing the grain as it goes into the wagon. It may also be similarly used for weighing potatoes as they are harvested.



THE DERRICK SCALE

Fig. 17. The sled runners are oak joists two inches thick, ten inches wide and eight feet long; the uprights are of any strong wood two by four inches and eight feet long; at the top they are bolted to a headpiece six inches thick, eight inches wide and eighteen inches long. The swivel or rowlock which carries the pole is made by blacksmith, the ears being one-half inch by two inches, and the tongue one and one-quarter inch in diameter by eight inches long. The swivel rests upon a washer let into the headpiece, and the split key which holds the swivel in place works upon a similar washer fitted in the lower side of the headpiece. The pole is twenty-four feet long and four inches in diameter at the swivel.

REWEIGHING

The most careful people make mistakes sometimes, and the produce of every plot in experimental work—at least the grain and potatoes—should be weighed the second time. To accomplish this the grain as it comes from the thrasher is weighed into sacks; these are tagged with the number of the plot and set aside, to be weighed again when there is less hurry than while the threshing is in progress. In a similar manner potatoes and corn may be gathered into tagged sacks, boxes or barrels, and weighed again. Both potatoes and corn should be separated into large and small, and in the case of corn it is advisable to count the ears, nubbins and stalks, separating these into those which bear one ear, those having two ears and those which are barren.

KEEPING THE RECORDS

PLANS, DIAGRAMS, ETC.

Before a field experiment is begun the land available should be carefully measured and a diagram of the experiment drawn to scale on paper. In connection with this diagram there should be a record book in which should be entered the dates of all operations and other items bearing upon the progress of the experiment, including the final outcome. It is never safe to depend upon memory nor upon field stakes for the plan of the experiment; for memory is proverbially treacherous and stakes are liable to be misplaced or lost. A very convenient way of entering the final results of an experiment which is continued from year to year is shown in the accompanying transcript from an actual record.

TABLE II. METHOD OF RECORDING PLOT WORK

Wheat grown in 5-year rotation of corn, oats, wheat, clover and timothy.

Plot 11	YIELD PER ACRE						INCREASE PER ACRE					
	GRAIN-BUSHELS			STRAW-POUNDS			GRAIN-BUSHELS			STRAW-POUNDS		
	Season	Total	Ave.	Season	Total	Ave.	Season	Total	Ave.	Season	Total	Ave.
1894	18.54	.....	.....	3,087	.....	.....	-0.42	.....	.....	991	.....	.....
1895	10.83	.....	.....	860	.....	.....	7.83	.....	.....	657	.....	.....
1896	9.04	.....	.....	1,057	.....	.....	7.76	.....	.....	784	.....	.....
1897	30.58	.....	.....	3,665	8,669	2,167	20.75	35.92	8.98	2,642	5,084	1,268
1898	33.67	102.66	20.53	3,110	11,779	2,356	17.71	53.63	10.73	1,581	6,655	1,331
1899	22.83	125.46	20.91	2,580	14,359	2,393	17.19	70.82	11.80	1,825	8,480	1,413
1900	11.67	137.13	19.59	1,120	15,479	2,211	10.67	81.49	11.64	977	9,457	1,351
1901	27.25	164.38	20.55	3,565	19,044	2,380	21.31	102.80	12.85	2,778	12,235	1,529
1902	37.33	201.71	22.41	2,710	21,754	2,417	26.97	129.77	14.42	2,045	14,280	1,587
1903	38.25	239.96	24.00	3,405	25,159	2,516	17.95	147.72	14.77	1,777	16,057	1,606

Under "season" is entered the yield for each successive year; under "total" is carried forward the aggregate yield for the entire period up to the date of entry, and under "average" is entered the average yield for the same period.

CORRECTING RESULTS

While it is highly desirable that an experiment should be so conducted that its results may be accepted just as they come from the field, there will sometimes be cases where some correction is needed in order to avoid a statement that would be actually misleading. In the case of corn and potatoes especially it is practically impossible to secure at all times a perfect stand, because of destruction of occasional plants by insects or from other causes. Where such cases occur it has been found better to count the hills or plants and make the corrections on the basis of the average stand actually attained, rather than upon that of the possible full stand. The former method gives results corresponding to the yield actually obtained, whereas the latter one always gives exaggerated results, since it appears that the destruction of a plant gives opportunity for surrounding plants to develop more freely and produce a yield larger than could have been obtained under normal conditions.

Fig. 18. Plan of experiment with fertilizers on corn, oats, wheat and clover, grown in 4-year rotation. Four sections, of ten plots each, in the test. Fertilizers applied to corn, oats and wheat. Plots 8 and 9 manured and fertilized only on corn.

Total constituents in 4 years

1. Unfertilized	
2. Acid phosphate, 160 lbs. per acre	$P_2O_5=68$ lbs.
3. { Acid phosphate, 160 lbs. per acre { Muriate of potash, 40 lbs. per acre	$P_2O_5=68$ lbs. $K_2O=60$ lbs.
4. Unfertilized	
5. { Acid phosphate, 160 lbs. per acre { Nitrate of soda, 80 lbs. per acre	$P_2O_5=68$ lbs. $N=38$ lbs.
6. { Acid phosphate, 160 lbs. per acre { Muriate of potash, 40 lbs. per acre { Nitrate of soda, 80 lbs. per acre	$P_2O_5=68$ lbs. $K_2O=60$ lbs. $N=38$ lbs.
7. Unfertilized	
8. Barnyard manure, 6 tons per acre	{ $P_2O_5=40$ lbs. $K_2O=60$ lbs. $N=60$ lbs.
9. { Barnyard manure, 6 tons per acre { Acid phosphate, 200 lbs. per acre	{ $P_2O_5=68$ lbs. $K_2O=60$ lbs. $N=60$ lbs.
10. Unfertilized	

CALCULATING INCREASE

An old soil which, from surface indications, is apparently uniform, may nevertheless show considerable variations due to previous treatment. This is shown by the accompanying diagram (Fig. 19), which shows the average yield of four plots which have received for ten years fertilizers containing the same quantities each of nitrogen, phosphorus and potassium, together with the yield of three adjoining unfertilized plots, the plots being arranged as indicated by the numbers. It will be seen that where we assume the variation between consecutive unfertilized plots to be uniformly progressive we get a practically uniform increase from the different fertilizers, but if we should strike a general average of all the unfertilized plots there would be no consistency in the results. The variation in the unfertilized yield in this case was due to the fact that the land occupied by Plot 28 and parts of the adjacent plots was not brought into cultivation until many years after that occupied by the other plots of the series; but about seven years before the test began all had been thrown into the same field, and when the test began there was no superficial indication of previous differences in treatment.

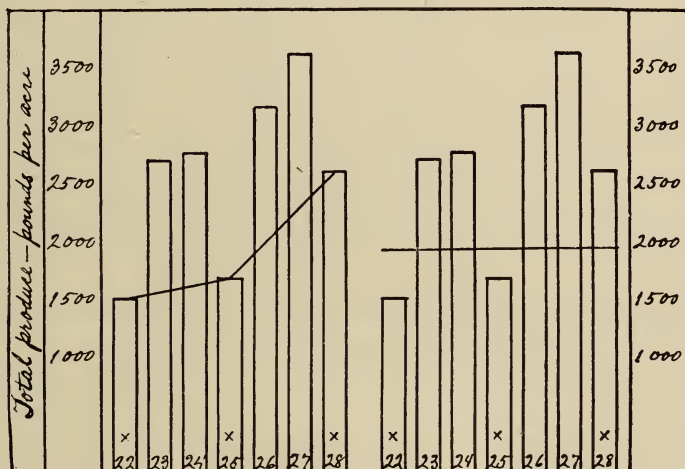


Fig. 19. When every third plot is a check plot the difference in yield between the two successive checks is found, and one-third of this difference is added to the smaller yield of the two checks or subtracted from the larger yield, the result being assumed to be the *natural* yields of the two plots lying between the checks. The difference between this assumed yield and the yield actually obtained is taken as the increase or decrease resulting from treatment.

CONTINUITY OF WORK

Few of the questions which demand solution by field experiment can be definitely answered by a single season's test. The unequal effect of rainfall on soils differently situated with respect to natural drainage may produce wide differences in the apparent results of a test in different seasons. Other climatic variations may produce

similar variations in results, so that an experiment must be carried through a number of seasons before its results can be accepted as a reliable guide.

This point is illustrated by a test showing the increase or decrease in yield of wheat on several plots in 1894, and in the average for ten years. It will be observed that in the general average acid phosphate and nitrate of soda are the most effective constituents of the fertilizer, but that their effect has varied greatly in different seasons, acid phosphate producing an actual loss of crop in 1894. Had this experiment been limited to a single test in 1894 it is evident that a wholly erroneous opinion of the effect of acid phosphate on this soil would have been formed.

Tables III, IV and V show the varying effect of fertilizers over a long period of years on poor soil and on good soil. In most of these seasons phosphorus is unmistakably the chief agent in producing increase of crop; but in 1894, on the poor land, potassium takes the leading place, and in 1903 nitrogen comes to the front, while on the good land there has been still greater variability in the apparent effect of the three fertilizing constituents.

Another reason for continuity of work in experiments with fertilizers is the fact that the full effect of such fertilizers is seldom realized in the crop to which they are applied. This point is shown by Table VI, giving the average increase from fertilizers in a test which has been in progress for ten years, the figures opposite each year being the average result for the entire period up to and including that season. In this case there was a comparatively steady yield on the unfertilized plot, with a constantly increasing yield from the fertilizers.

TABLE III. EFFECT OF FERTILIZERS ON WHEAT IN DIFFERENT SEASONS.

Wheat in rotation with corn, oats and timothy on poor soil.

PLOT	FERTILIZERS	INCREASE (X) OR DECREASE (-) IN BUSHELS PER ACRE	
		1894	10-YEAR AVERAGE
2	Acid phosphate.....	-2.80	× 6.48
3	Potassium chlorid.....	×5.63	× 1.25
5	Sodium nitrate.....	-1.22	× 1.82
6	Acid phos. and nitrate.....	-4.65	×11.40
8	Acid phos. and potassium.....	-1.11	× 8.26
9	Mur. potash and nitrate.....	×3.53	× 2.38
11	Acid phos., potassium and nitrate.....	-0.42	×14.77
12	" " " " " ".....	×0.42	×15.92
14	" " " " " ".....	-1.42	×13.01
15	" " " " " ".....	-1.25	×12.42
23	" " " " " dried blood.....	-0.06	×11.70
24	" " " " " sulphate ammonia.....	×0.89	×11.33
26	Bone meal, potassium and nitrate.....	-3.06	×11.70
27	Dissolved bone black, potassium and nitrate.....	-5.36	×14.37
29	Basic slag, potassium and nitrate.....	-2.08	×13.30

1894 was the first year of the test and was the only season of the eleven years ending with 1904 when the combination of acid phosphate and nitrate of soda failed to produce a large increase.

Table III shows a decrease in yield on all plots fertilized with acid phosphate in 1894 except two. Plots 12 and 24, where acid phosphate, used in combination with other fertilizing materials, shows a slight increase, the gain however being so small as to be almost negligible, yet in the 10-year average acid phosphate has evidently been the most effective of the three materials used in producing increase of crop.

Table IV shows the varying effect of different fertilizing constituents in successive seasons on *poor* soil.

TABLE IV. EFFECT OF FERTILIZERS ON WHEAT IN DIFFERENT SEASONS

Wheat in rotation with corn, oats, clover and timothy on poor soil.

YEAR	YIELD AND INCREASE IN BUSHEL PER ACRE				
	Unfertilized Yield	INCREASE OR (*) DECREASE OVER UNFERTILIZED YIELD FROM—			
		Acid Phosphate Plot 2	Potassium Chloride Plot 3	Sodium Nitrate Plot 5	Plots 2, 3 and 5 combined
1894	19 29	*2.80	5.63	*1.22	*.42
1895	2.98	4.69	*1.02	1.42	7.83
1896	1.06	3 10	.74	.48	7.76
1897	10.43	7.02	1.81	4.83	20.75
1898	12.63	3.70	1.05	2.21	17.71
1899	6.86	5.92	1.91	1.94	17.19
1900	1.08	10.62	.55	1 20	10.67
1901	5.90	17.25	*.17	.11	21.31
1902	10.55	13.06	2.86	1.75	26.97
1903	18.34	2.16	*.83	5.50	17 95
Average.....	8.91	6.48	1.25	1.82	14.77

Injury from Hessian Fly in 1895, 1896, 1899, 1900 and 1901.

Table V shows the varying effect of different fertilizing constituents in successive seasons on *good* soil.

TABLE V. EFFECT OF FERTILIZERS ON WHEAT IN DIFFERENT SEASONS.

Wheat in rotation with potatoes and clover on good land.

YEAR	YIELD AND INCREASE IN BUSHEL PER ACRE				
	Unfertilized Yield	INCREASE OR DECREASE (*) OVER UNFERTILIZED YIELD FROM—			
		Acid Phosphate Plot 2	Potassium Chloride Plot 3	Sodium Nitrate Plot 5	Plots 2, 3 and 5 combined
1895	7.51	7.53	1.06	1.98	8.03
1896	7.42	4.52	1.56	2 63	8.14
1897	34.16	.97	3.11	3.44	8.44
1898	22.99	4.10	2.65	1.21	9.36
1899	25 88	1.53	2 39	2 25	9.75
1900	37.90	4.03	6 30	*1.45	2.33
1901	24 25	3.38	*1.10	*4.13	3.56
1902	36.23	6.83	.26	1.36	16.47
1903	26.75	3.80	*2.69	5.67	11.08
Average.....	4.14	4.19	2.10	1.43	8.57

Injury from Hessian Fly in 1895 and 1896.

Table VI shows the cumulative effect of systematic fertilizing; each season's increase being sufficient to raise the average increase for the total period to a higher level.

TABLE VI. PROGRESSIVE INCREASE FROM FERTILIZERS.

Increase in bushels per acre.

PLOT II. COMPLETE FERTILIZER	CORN	OATS	WHEAT
Average increase for 3 years ending 1896.....	8.45	12.08	5.06
“ “ “ 4 “ “ 1897.....	8.74	13.57	8.98
“ “ “ 5 “ “ 1898.....	10.72	12.92	10.73
“ “ “ 6 “ “ 1899.....	11.20	14.51	11.80
“ “ “ 7 “ “ 1900.....	12.60	15.92	11.64
“ “ “ 8 “ “ 1901.....	14.48	17.21	12.85
“ “ “ 9 “ “ 1902.....	15.18	17.98	14.42
“ “ “ 10 “ “ 1903.....	15.07	18.33	14.77

SUMMARY

The experiment station stands for organized research, does things impossible to the ordinary farmer, and formulates general principles. The farmer must make the application. The farmer who profits most by the experiment station must himself be an experimenter.

SELECTION OF SOIL

The *geological history* of a soil is of importance as an index to its general character. *Previous management* may have an important bearing upon the results of an experiment, as shown by long-continued effect of manuring at Rothamsted. In *topography* an experiment field should not be absolutely level nor very steep; a broad, gentle slope of 1 or 2 percent, or just enough to permit uniform surface drainage, has been found best.

ARRANGEMENT OF PLOTS

The most convenient *size of plots*, for most purposes, is one-tenth acre. This size is convenient for computation, and holds a sufficient number of plants to eliminate the errors arising from individuality if care be taken in seed selection. The inequalities of soil can be better eliminated by duplicating the test in small plots than by the use of large plots. In *shape*, the plots should be long and narrow. It is well to adjust the width to the convenient use of machinery and to the scheme of drainage.

Surface drainage must be provided for, and this can be most easily done by making the plots comparatively narrow and slightly ridging them. *Underdrainage* is absolutely necessary on moist soils. *Division spaces* need not be more than 2 feet wide, provided they are the dead furrows made in ridging the plots. *Old ridges and dead furrows*, when running lengthwise of a plot, may reverse the results

of a test, hence plots should be laid out across the direction of previous plowings. *Cross drainage* should be carefully avoided in fertilizer tests. *Cross feeding* may be prevented by separating the plots by dead furrows. The repetition of *check plots* is a matter of first importance. Every third or fourth plot should be used as a check. The *boundaries* of every block of experiment plots should be permanently marked with stakes that will not be thrown out in plowing. *Headlands and roadways* should be left around every block of eight or ten plots, so that teams may be turned without trampling the plots, and every plot should be distinctly marked with a label stake.

PREPARATION OF LAND FOR CROPS

Uniformity of treatments is of first importance. A difference of a few days or weeks in date of plowing may cause as great a difference in yield as any difference in variety or fertilizing. *Manures and fertilizers* should be applied by machinery with special care to get each application wholly on its plot and uniformly distributed. Lime may be applied with a special lime distributor or with manure spreader. All *machinery should be accurate*, whether for seeding, harvesting or thrashing. *Selection of seed* is a matter of importance. Seed of low vitality will not give a proper stand, nor will seed that is uneven in size, hence the tips and butts of seed corn should be rejected and the small grains should be graded. *The rows should be straight*, especially with the small grains, for when the rows crowd each other the yield will be reduced. *The entire plot should be planted*, and to accomplish this the small grains should be drilled beyond the plots, cutting away the excess before harvest.

PLANTING AND CULTIVATING

Machine work is preferable wherever it can be employed, as it is more accurate and uniform than hand work, whether for planting, cultivating, harvesting or thrashing.

HARVESTING

Grass plots may be mown by driving the machine to stakes set so that the nose of the machine will just reach the outer edge of the plot. For *harvesting grain crops* the plots should be arranged in blocks of eight or ten, with 12-foot roadways between, so that the machine may not be driven over the plots except when actually cutting. In all cases a gleaner should follow the machine, to keep the produce of each plot on the plot itself.

WEIGHING

Hay and grain may be weighed on the ordinary wagon and stock scale. Several plots may be loaded on the wagon, separating them by sheets, and weighing again after each one is unloaded; but a

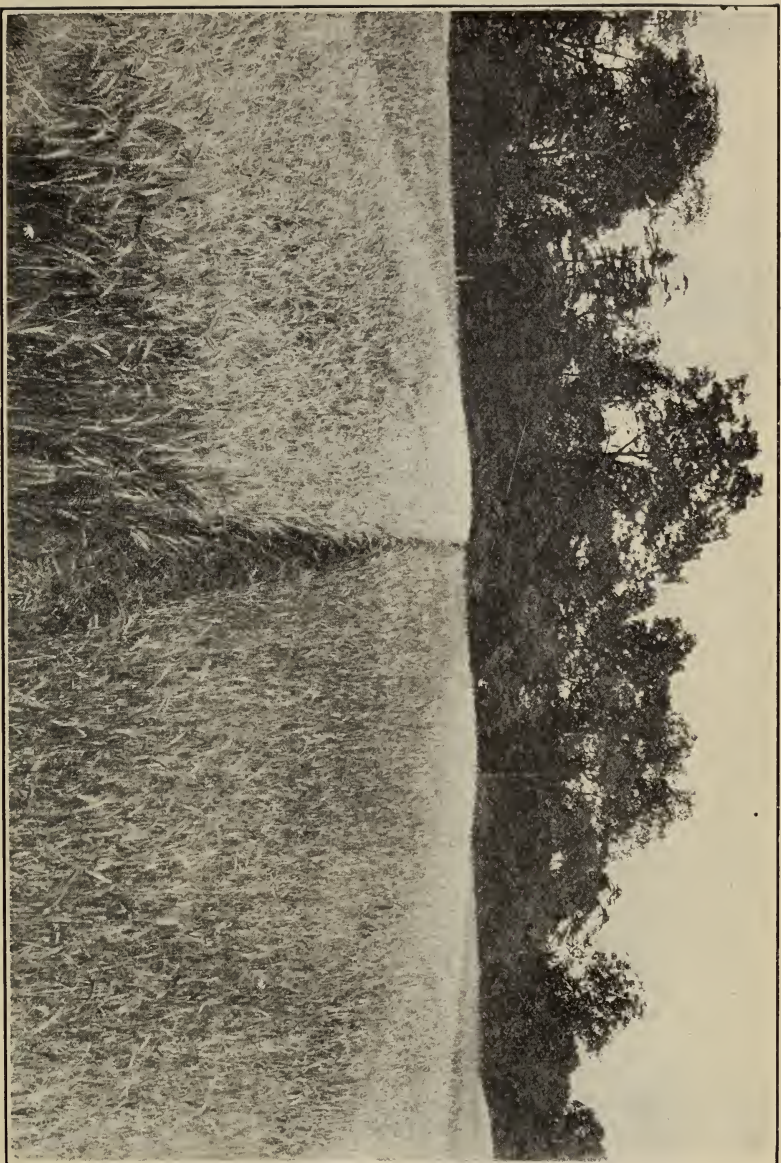
cheaper and better weighing arrangement is the *portable derrick scale*, a common weigh beam suspended to the shorter end of a long lever, which is pivoted on a small derrick carried on a sled and moved from place to place as needed. All weights of grain or potatoes should be verified by setting the produce of each plot aside in a tagged sack or barrel and *reweighing* at leisure.

KEEPING THE RECORDS

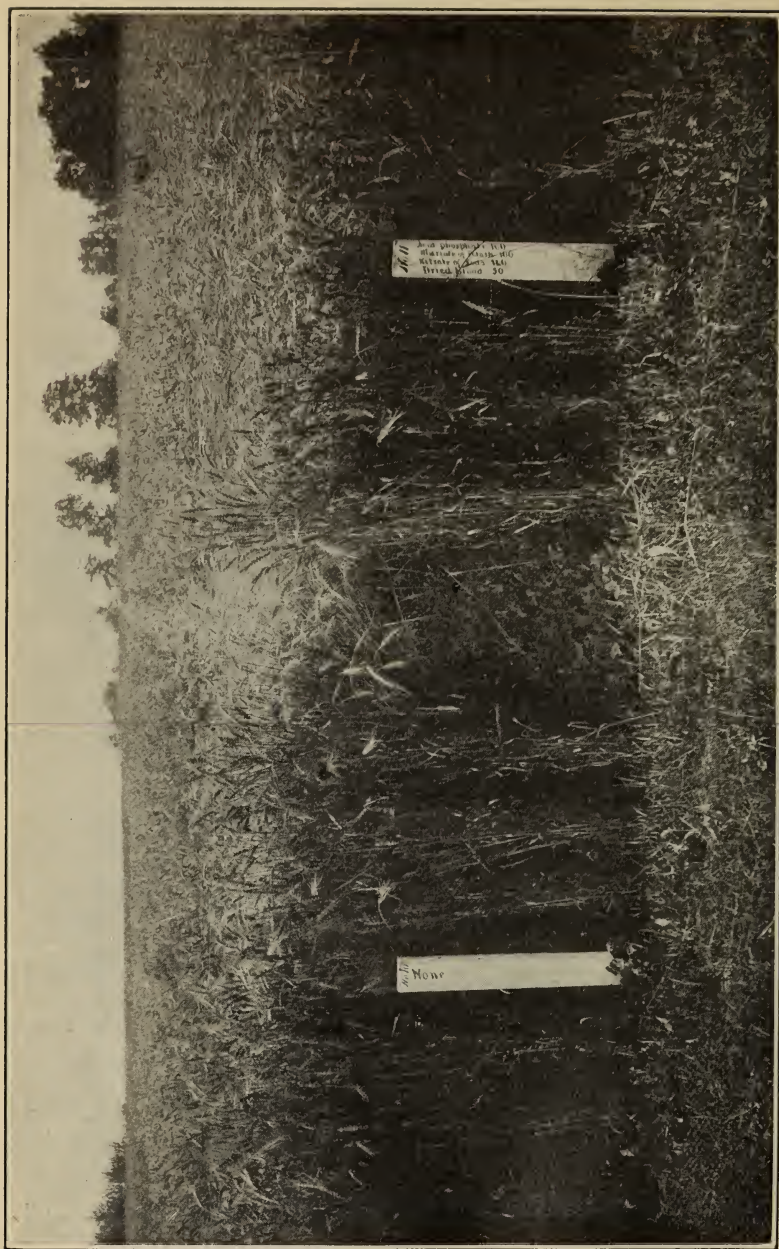
A complete *plan* of each experiment should be made on paper before the work in the field is begun, and every operation should be entered in a record book kept for the purpose. It is sometimes necessary to *correct the results*, and it is better to base this correction upon the average actual yield rather than the possible full yield. The *calculation of increase* should be made on the assumption that the variation between neighboring check plots is due to similar variations in the soil between them. It is never safe to assume that one or two check plots will sufficiently indicate the character of the soil of a large field, nor that the general average of a series of such plots will do so.

CONTINUITY OF WORK

This is of first importance in field experiment. The result of one season's test may be the direct opposite of the average outcome of a period of years, and as a general rule the full effect of the fertilizer or manure can only be determined after a series of years.



Plots 6 and 7 in 5-year rotation, 1905. Yield per acre: Plot 6, 21.33 bushels; Plot 7, 4.42 bushels. A part of Plot 5 is shown in the upper left hand corner, and of Plots 8 and 9 in the right hand corner, with a small part of Plot 11 at the extreme right.



Plots 10 and 11 in Potatoes-wheat-clover rotation, 1906. Yield per acre: Plot 10, unfertilized, 46.46 bushels.
 Plot 11, complete fertilizer, 52.33 bushels.

Ohio Agricultural Experiment Station

CIRCULAR No. 97

WOOSTER, OHIO, JANUARY 30, 1910

THE WORK OF THE DEPARTMENT OF COOPERATIVE EXPERIMENTS

BY L. H. GODDARD

INTRODUCTION*

"The experiment station is the distinguishing feature of the new agriculture. It stands for organized research in agriculture; for the concentration of the skill and energy of the entire State on the solution of the unsettled problems of the farm.

"The experiment station is created to do things which are impossible to the ordinary farmer. It is furnished with costly equipment and conducted by men trained in the methods of scientific research, who are made free from other cares in order that they may devote their undivided energies to helping the farmer.

"But while there are some things which can only be done by the aid of such an equipment as that of the experiment station, there are other things which the station can never do, and the farmer who profits most by the work of the experiment station is he who is himself an experimenter.

"It is the province of the experiment station to discover and formulate general principles. The application of these principles must be made by the farmer himself. Even were there an experiment station in every county, there would still be hundreds of farms within each county on which some of the conditions would vary from those of the station, and while no farmer should attempt to duplicate the elaborate work of the experiment station, neither can any farmer afford to blindly accept the conclusions reached at the experiment station without subjecting some of them to the test of further investigation on his own farm.

"Were there no other reason for this than the benumbing effect upon the intellect produced by the unthinking acceptance of the dicta of others, as evidenced by the unnumbered centuries during which the sickle remained unchangingly a chief implement of husbandry, this unchangeableness symbolizing a similar monotony in

* By Director C. E. Thorne, Circular 96, Ohio Experiment Station.

the farmers' intellectual processes, that alone would be abundantly sufficient. The farmer of today must learn to think or he is lost, and nothing is more conducive to exact thinking than scientific experiment.

"The experiment station should carry its work far enough to demonstrate clearly the lines which practical application must follow, but after it has reached its uttermost limit there will still be much for the farmer to do."

ORGANIZATION

In order to help the farmers of Ohio derive a greater benefit from the work of the experiment stations and other similar institutions, there was organized at the Ohio Experiment Station in 1904 a Department of Cooperative Experiments, the immediate purpose of which was to assist in the making of experiments on the farms throughout the State, as suggested above.

In the earlier years, partly because of limited funds, the work of the Department was confined quite largely to field experiment work, in which small plots of one-eightieth acre or less were used, and for which arrangements were made almost entirely by correspondence. Thus was continued, with but slight change, the experiment work of the Agricultural Students' Union,* which, by special arrangement with the Union, was taken up by the Experiment Station upon the organization of the Department. At the present time the Department's functions have come to include, in addition to a modified form of this experiment work, fair exhibits and farm management investigations. In the following pages will be outlined the work as it is proposed to conduct it in 1910, providing the necessary funds are appropriated by the legislature at its present session.

FIELD EXPERIMENT WORK

In the field experiment work of the Department great care is taken to see that the experiments are so outlined that they will fit into regular farm work. It is of course recognized that no experiment worthy of serious consideration can be made which will not require some extra work and attention. But on the other hand, one who is familiar with farm conditions and experiment work as well, can usually plan an experiment which will be fairly easy of execution and yet quite valuable to the farmer, even though it may not be of special value as a scientific investigation. The assistants in charge of the field work of the Cooperative Department have all had experience as farmers. In planning cooperative experiments they always aim to make primary the immediate interests of the cooperator and his neighbors.

* See Bulletin 88 and Circular 47, Ohio Experiment Station.

It is deemed that the adaptability of a given method or variety of a crop to a section is finally determined by its adoption or nonadoption by the farmers of that section after they have had the opportunity to study it in a field experiment on their own farms under their own control. No set of figures from experiments conducted elsewhere is nearly so convincing to most farmers as a local field trial of this kind. It is in the province of the scientific departments of the Experiment Station to conduct scientific field experiments on land which it either owns or controls and to report the results of the same to the world. But the province of the Cooperative Department, so far as field experiments are concerned, is largely to assist the farmers to make experiments themselves on their own farms. The Department helps them by outlining plans and furnishing part or all of the material for the experiment, but the execution of the work is entirely in their own hands. The experiments used in this work may for convenience be classified as follows: small plot, large plot, observation and quantitative. With these experiments may also be classified the multiplying work.

Large and small plot experiments. The large and small plot experiments are, as the names indicate, simply those in which the plots used are either large or small. In either case the size of the plots vary. The smallest plots are probably those used in the potato variety test, in connection with which enough seed of each variety is supplied to plant two rows, each two rods long. In the large plot tests the plots vary in size from one-tenth to one or more acres. The size of the large plots in all cases is determined by the conditions under which the test is to be made. It is the aim, for instance, to make each plot one or more drill or planter rows clear across the field; or, to make the entire test utilize a given area which is specially suited by location or otherwise to the purpose. In most cases material will not be supplied for a large plot test unless a representative of the Department has first visited the site of the proposed work and arranged with the ^{owner} manager regarding all the details.

The observation test. The observation test is one regarding which the report to the Experiment Station is based upon the judgment of the cooperator, no exact figures as to weight of produce being required. Quite a large percent of the cooperative field tests come in this class. It is specially adapted, for instance, to trying out a number of varieties of wheat or oats that have never been grown in a given section. By watching closely the habit of growth of a number of different varieties of these crops for a few seasons, even on small plots, a close observer can easily pick out the poorer ones for the existing conditions, and can then limit further

and more careful experiments to the better ones. The plots of the observation tests are not always small. In connection with the pasture work, for instance, they are frequently an acre or more in size. This depends partly on the nature of the test and partly on the conditions under which it may be made.

The quantitative test. The quantitative tests are those regarding which the cooperator is asked to determine, in pounds or some other appropriate standard of measure, the exact quantity of crop produced on each plot. They are of course the hardest of all for a farmer to make, yet one of the most popular of the Department's tests is that with the potato varieties, which has small plots so arranged that the results are of much scientific value. A modified form of the observation and quantitative tests is that in which one or more small areas of each of the large observation plots are harvested separately and exact weights of produce on same determined to serve as a check on the judgment of the eye in making the observation report.

Multiplying work. After having determined by field experiments that a certain crop or variety of crop is suited to their soil and conditions, most farmers will wish to establish that crop on their farms. In case it is a cereal crop they can do this by purchasing seed from a grower of it with whom the Experiment Station will try to put them in touch. The name and address of the individual or firm from which the Station procured the seed which it uses in cooperative work is always given on the shipping order, a copy of which is always sent to the experimenter with his material.

In case the crop is produced by the Station itself, it will undertake to help cooperators establish the same on their farms, by supplying them without expense with a small amount of the seed, with the understanding that they will take all reasonable care to keep the seed as pure as it was supplied to them, and will sell the produce of it, as soon as their own wants have been supplied, at reasonable prices, to their neighbors or to others who may be referred to them. The Experiment Station itself will sell no seed, but if farmers wish to procure seed in larger quantities than the Station can supply in this multiplying work, they can in many cases secure it from persons to whom seed has been supplied for multiplying purposes in former years.

The work as conducted in 1909, for which the Station supplied part or all of the material, and which will doubtless be continued without material change in 1910, includes the following lines:

LINES OF FIELD EXPERIMENT WORK

Kind of Work	Small Plot	Large Plot	Observation	Quantitative	Multiplying
Corn	S	L	O	Q	M
Wheat	S	L	O	Q	M
Oats	S	L	O	Q	M
Soybeans	S	...	O	Q	M
Potatoes	S	...	...	Q	...
Fertilizers	S	L	O	Q	...
Lime.....	S	L	O	Q	...
Alfalfa.....	S	L	O	Q	...
Grasses	S	L	O	...	...
Formalin for oat smut.....	...	L	O	...	...
Tanglefoot for canker worm.....	S	...	O	...	...
Strawberry	S	...	O	...	...
Plant Breeding.....	S	L	...	Q	...
Forestry	...	...	...	...	...
Miscellaneous.....	...	...	...	...	...

The work in connection with each of the items listed usually includes several different features. For instance, with corn there are grain and silage variety tests, tests of thickness of planting and date of planting, breeding work, etc. Persons interested in any of the crops or work named, and wishing to take up work along any line regarding them, should write to the Station for details for which there is not space in this circular. As indicated by the term "Miscellaneous," the work is not necessarily limited to the above named features. It is the Experiment Station's desire to help farmers, so far as possible, along all lines in which they are interested. All are therefore invited to communicate their desires to the Station, even though not referred to in this list, and if possible special tests will be planned for them. If it should not be possible to grant the request no harm will be done. The forest-tree planting work, which for a number of years was conducted through the Cooperative Department, has now grown to such proportions that in 1909 the Department's only connection with it was that in regard to shipping, and even this will probably not be necessary in 1910. The alfalfa and grass work has been and probably will continue in cooperation with the Office of Seed Distribution of the Bureau of Plant Industry, United States Department of Agriculture.

County tests. A very interesting phase of the corn work in 1909 was the large plot variety tests, which were conducted in cooperation with a number of the county corn improvement associations. In these tests each grower of good corn in a given section was invited by the Association in that section to supply a sample of his corn to be tested for yield in a field plot test, side by side, with that

supplied by the other growers of his section and with varieties from a distance which were supplied upon request by the Experiment Station. Strange as it may seem, the different varieties that are in use in the same neighborhood will vary in yield from each other from 15 to 35 bushels of grain per acre, when planted side by side in a field test in this way. This work includes silage as well as grain production. In all, fourteen counties took up the work in 1909—Butler, Warren, Mercer, Logan, Putnam, Van Wert, Huron, Lake, Columbiana, Franklin, Hardin, Fairfield, Belmont and Meigs. A number of these counties had duplicate tests, one having the work duplicated on fourteen different farms.

County field meetings. A valuable feature in connection with these tests is the small field meetings at which all persons interested in the test, together with a representative from the Station, gather several times within the crop season to examine and make record of the condition of the various plots. It is probable that the greatest value of a corn show is to get farmers together to talk corn, also that after the first few shows in a neighborhood the actual judging of the corn and the awarding of prizes is more or less of an injury because of the inability of the judge, after the farmers have improved their corn to a certain point, to determine which is really best. In these county field tests the judging is done by the soil, thus robbing the meeting of the injury above mentioned. On the other hand, there is a better opportunity to talk corn with the growing plants before them than there is at a corn show. This work should be considered carefully by every association in the State before determining upon plans for 1910. It need not be confined to corn alone. Tests with potatoes were also taken up in a similar manner in 1909. It may be well to include fertilizers, alfalfa, grasses, soybeans or any other suitable crop.

FAIR EXHIBITS

For a number of years the Experiment Station has been making exhibits at county fairs. These exhibits are not of the kind made by individuals. They do not enter into competition for prizes, but are to illustrate in a concrete manner the improved methods that have been developed by the Station for increasing the net value of crop and animal production. So far as possible, the actual material regarding which the information is to be given is used in making up the exhibit.

For this exhibit there is needed a well-lighted building or tent not less than 40x60 feet in size. A representative of the Station is always on hand the Monday morning preceding the fair to install

the exhibit, and throughout the busy days of the fair the Station provides three or four men to explain the exhibit to those interested. All this is without expense to the county agricultural society other than that connected with supplying the building or tent, drayage to and from the railway, lumber for shelving, carpenters, etc.

In 1909 two exhibits were maintained in the field throughout the fair season—twenty fairs being reached. In the estimate which has been presented to the legislature for the work of the Cooperative Department in 1910, provision has been made for a third exhibit. Further information regarding the fair exhibit work will be given in a circular which is now being prepared and which will be supplied upon request as soon as issued.

FARM MANAGEMENT INVESTIGATIONS*

The Cooperative Department is also making a study of the rotations, cropping, feeding and business methods that are in use upon the farms throughout the State. If the farmers of Ohio are to keep pace with the advancing prices of land and labor they must not only have the best crops and livestock for their conditions, but they must also use the best methods in handling them. It is probable that all these are being used, in piece-meal at least, somewhere within the state. To find these practical illustrations of advancement and introduce them to all is what the Department is undertaking to do.

Cost of production. In order to determine the cost of production of crops and livestock, a number of farmers are reporting to the Station in detail regarding each half-hour of time and each cent of money expended on their farms and all income therefrom. Cooperators in this work are supplied with suitable blanks and receive monthly statements for their farms showing the distribution of labor by field, by operation and by crop or enterprise, and, later in the season, a summary for the important crops.

Enterprise work. A number of other farmers are reporting this information regarding a single enterprise on their farms, such as the dairy, the poultry or a single crop. In the *dairy* work each cooperator is supplied with a Babcock milk tester, scales, sampler, blanks, etc., and reports each month the produce of and the feed consumed by each cow in his herd. On the basis of these reports the Department prepares and supplies to the cooperator each month a statement showing the total pounds and value of milk and butterfat produced and of feed consumed by each cow.

* A part of this work is in cooperation with the Office of Farm Management of the U. S. D. A. Bureau of Plant Industry.

Circulars are now being prepared regarding the dairy work up to the present time, the varieties of corn now being grown in the state, the cropping and business methods used in growing orchard grass, and regarding minor farm equipment. As soon as issued these will be mailed upon request.

Farm examinations. Hereafter upon request the Station will undertake to have a representative visit farms throughout the State, to make a study of them and outline cooperative experiments which will enable the farm manager to determine for himself with accuracy whether or not changes in his plans or methods are advisable. Applicants for these examinations must not expect to receive off-hand advice. Counsel not based on complete and accurate information such as these experiments, considered in connection with experiments made elsewhere, will afford, usually would be of little value. Applications should be made as far in advance as possible, so that visits may be made in circuits to save time and expense.

Agricultural survey. All the information that may be gathered by any phase of the Department's work will be assembled from time to time to contribute to an agricultural survey of the State, which is now being conducted by the Experiment Station. For some time, in furtherance of this end, and because of the diversified conditions existing in many of the counties, all reports to the Department have been recorded by township instead of by county. In this connection may be mentioned a circular, now being prepared, which will show graphically, by township, the statistics of farm products for the whole state, and which is based upon the statistical reports made to the State Board of Agriculture by the township assessors.

Messrs. M. O. Bugby, Gail T. Abbott, W. A. Lloyd and W. M. Cook have charge of the cooperative field work in separate districts of the State, and also of certain phases of the farm management investigations that have been assigned to them for study and report. Mr. W. L. Elser has charge of office record and statistical work.

The preceding statement of the work of the Department of Cooperative Experiments has necessarily been made brief. It is hoped, however, that all persons interested will be so kind as to give the Station an opportunity to explain further regarding any phase of it.

Ohio Agricultural Experiment Station

CIRCULAR No. 98

WOOSTER, OHIO, FEBRUARY 1, 1910

MINOR ITEMS OF FARM EQUIPMENT

INTRODUCTION

This circular regarding the Minor Items of Farm Equipment, which has been prepared by Mr. L. W. Ellis of the Office of Farm Management Investigations, United States Department of Agriculture, Bureau of Plant Industry, in cooperation with the Ohio Experiment Station, is based entirely on inventories taken either by himself or by members of the Ohio Station staff upon thirty-three Ohio farms that are well distributed throughout the State. It would seem, therefore, that his statement that "The minor items for a general farm of 160 acres in Ohio and other Middle-Western States will probably cost from \$200 to \$300 by the time the equipment is complete," instead of \$25 to \$50, as many of us have assumed, should at once challenge our serious consideration. An error of five hundred percent or more in our calculations, especially when it is on the wrong side of the account and runs into the hundreds, is indeed serious, and surely the suggestion by a good authority that such an error does exist should inspire many of us to check the figures that have been given us with the conditions upon our own farms.

In order to facilitate this checking it has been arranged to have the tables on pages 11 to 15 inclusive set with two extra blank columns marked "Number" and "Price of Each" respectively. It is hoped that a few of Ohio's progressive farmers will use these columns to take an inventory of their own minor equipment and that they will favor the Experiment Station with a copy of same. If the original is sent to the Station it will undertake to have the computations made and to return a copy to the sender. If more inventories are received than can be cared for promptly the originals will be returned to the senders without delay. Any variation from the figures or totals as given by this circular will not be taken as captious criticism either by the United States Department of Agriculture or by the Ohio Experiment Station. Both institutions wish to know the facts. The present statement is based on inventories from thirty-three farms only. If figures from a much larger number of farms can be secured the value of future deductions will be correspondingly increased.

L. H. GODDARD.

MINOR ITEMS OF FARM EQUIPMENT

• By L. W. ELLIS
•

Among the leaks in farming to which—because of their apparent unimportance—little attention has been directed, is the waste which occurs through a general lack of comprehension as to the extent and value of the small items which are necessary to the smooth running of the farm. This waste exhibits itself in extra expense through the purchase of unnecessary items; loss of time and discounts in buying numerous articles singly or in small lots; loss, theft and rapid depreciation of items considered too insignificant to require systematic care; and, if the farm is insufficiently equipped, in the losses in many directions through the lack or misplacement of equipment at times when it is urgently needed.

A previous publication (*) has to a greater or less extent emphasized all the foregoing points in discussing the advantages to be gained from having on the farm at all times the workshop tools and materials necessary for keeping in a high state of efficiency the equipment upon which the successful management of the modern farm so largely depends. It is the purpose of this circular to lay even greater emphasis upon certain of these points, and to present the results of a study made for the purpose of determining the amount and cost of all minor items of equipment necessary for a farm of general type. This study did not include wagons, machinery, or other articles which through bulk or value would be classed as items of major importance, but was confined to the consideration of the miscellaneous small tools, utensils and sundries usually purchased singly or in small groups at a slight cost per article.

The total cost of the miscellaneous articles is usually much higher than the estimates given by farmers and writers on agricultural subjects but, owing to the great number of small purchases made, is seldom realized except by the few who have made careful inventories at stated intervals. The ignorance of this fact leads farmers in general to neglect an extremely valuable portion of their equipment, and it would probably be found that the decrease in value of the small articles is much more rapid than that of the

* U. S. Department of Agriculture Farmers' Bulletin 347, "The Repair of Farm Equipment". This bulletin discusses the importance of making minor repairs on the farm, and the character and use of tools, workshop facilities and materials for repair work. It will be sent free on application to the Secretary of Agriculture, Washington D. C.

major items, for which an annual rate of depreciation of 7.3 percent has been established. (*) The low estimates regarding this portion of the equipment also prove disappointing to the manager of a new farming venture who finds it necessary to make an increased outlay on this account, attended by readjustment of his plans.

The importance of having a good working equipment in small items, and the absolute necessity for caring for it, are matters which should be apparent to the thoughtful farmer, and need not be dwelt upon further. The waste of time in making numerous special trips for small articles is also apparent, especially so when it is considered that many of these occur in the busiest seasons. This could be avoided to a large extent by taking an inventory during a slack period and replacing all missing items at the next opportunity. Concerning the loss through ignorance of what is needed, however, less has been said, and it is to the requirements in miscellaneous items and the purchase thereof that this circular will be largely devoted.

In selecting the minor equipment for a given farm, consideration must be given not only to the items needed for the care and repair of buildings, fences, machinery, etc., but to those used for the care of livestock, the production of crops, and various other interests of the farm. With every change in type of farm involving a new combination of enterprises a change in minor equipment will be necessary. For each of the many specialized types of farms certain articles will be needed which will not be found on the general run of farms. To attempt to determine the equipment in small items necessary for all these special types is beyond the scope of this circular, which will attempt to cover only those items found in most common use on farms of the general type. By this is meant a farm of moderate size on which both crops and livestock are raised without particular emphasis on the production or disposition of any one product.

The nature of minor equipment will be determined largely by the character of the farm enterprises and the distance of the farm from repair and shopping facilities, while the extent may be governed by the size of the farm, the number of workmen and the financial circumstances of the proprietor. Perhaps both will be influenced most by the latter's attitude with regard to small economies, and his ability to use tools to the best advantage.

* U. S. Department of Agriculture, Bulletin 73, Bureau of Statistics.

CLASSIFICATION OF MINOR EQUIPMENT

For convenience in considering the small items which go to equip the farm they may be classified according to use in connection with different enterprises.

On every farm, however, there are many articles used in the administration of the entire farm rather than for the conduct of any one enterprise. This general purpose equipment would include the articles already mentioned for the repair of the equipment, including the wood working and metal working tools, and certain repair materials such as wood, iron, paint, oil, etc. The weighing apparatus, tools for drainage and fencing, stone working tools, and many items which cannot easily be classified will also be listed as general purpose equipment.

A strict classification of miscellaneous articles according to use cannot be made because of the varying uses to which the same articles are put on different farms. For instance, certain tools connected with the garden, orchard and dairy, may be either household or farm equipment, depending on whether these are enterprises conducted simply for supplying the wants of the family or for the production of marketed products. Butchering tools would come under both classes where animals are slaughtered in excess of the needs of the family. On a majority of general farms, however, the butchering, orchard, garden and lawn equipment would pertain to the household, rather than to the producing enterprises, while the dairy equipment and ice tools might be both household and farm equipment at different seasons of the year.

Certain articles can be attributed directly to the presence on the farm of a given class of livestock, but many others are used in connection with several classes of stock, and still others may be used in connection with the stable rather than with the animals themselves. In consequence, in addition to classifying articles as equipment for horses, cattle, sheep, hogs, poultry, and bees, respectively, there may be a classification designated as "all stock" equipment to include the last named articles. The same thing is true with regard to the equipment for crop production. As in the case of larger machinery there will be a class of "all crop" tools, etc., as well as the items needed especially for corn, hay, small grains, potatoes, or other crop enterprises.

LIVESTOCK EQUIPMENT

The minor livestock equipment will consist of the items used directly for the care and management of horses, cattle, sheep, swine, poultry, bees, etc. The items classified as "all stock equipment"

need not necessarily pertain to all of the classes of stock listed, but are regarded as being for the use of two or more classes, or for the care of the stables or other quarters used by the stock. Under all stock equipment would be included brooms, shovels, forks, rakes, pails, wheelbarrows, etc., used in caring for the stables; baskets and measures for feeding; hand spraying apparatus for sanitary purposes; and such things as blankets, brushes, curry-combs, clippers, halters, ropes, etc., which might be classified either as all stock equipment or as that for some special class of stock, according to the usage of the individual farm.

Under the general head of horse equipment there has been classified for convenience both the items used directly in the management of the animals, and those used in driving or working the same. Since horses are used for both power and breeding purposes it is difficult to separate the items which are used exclusively for the general purposes of the farm. Many of these will be dispensed with on certain farms, and considered necessary on others. Some may be regarded as personal rather than pertaining to the farm business, but since in the management of the farm a great deal of driving is necessary it seems fitting to include under the head of farm equipment the numerous articles needed for the care of the driving stock, vehicles, harness, etc.

The miscellaneous cattle equipment will consist of those few items which will be found on general farms for the management of stock cattle, and on some farms the dairy equipment will be regarded as belonging to the cattle enterprise. In some sections of the country there will be a few extra items on account of use of oxen for draft purposes, but these will not be found on many farms in the western states. On the comparatively few farms where cattle are fitted for show purposes a few articles such as clippers, cabinet scrapers, spoke shaves, etc., will be in demand for trimming the hair, horns, and feet of the show animals.

No veterinary instruments will be recommended under either horse or cattle equipment except the very simple ones which are found in general use. Naturally the farmer who is something of a specialist along any line will wish to equip himself much more heavily than the ordinary one.

The dairy equipment will, of course, vary extensively according to the extent of the dairy enterprise and the disposition of the product. Besides the separator, which is in general use among the more progressive farmers, there are on some farms the machines and utensils necessary for manufacturing cheese or butter on a large scale. From the majority of general farms, however, the

product is usually sold either as whole milk or as hand separated cream. In the case of the sale of whole milk the whole dairy equipment might consist of nothing more than a few pails, a strainer, and several milk cans. For a small part of the year butter may be made upon the farm and sold elsewhere. In such cases a small churn, thermometer, butter bowl, a few butter crocks, milk crocks or pans, a butter ladle, and occasionally a butter print might be added to the former list. For the manufacture on a larger scale of either butter or cheese considerable extra equipment would be necessary, and the farms in this case would probably be classified as other than of the general type. The items already listed may be found on a great many farms where dairying is not one of the principal enterprises, and it is of this type of farm rather than the specialized plants that we wish to treat in this circular.

On farms where only a few sheep are kept one or more pairs of shears are frequently the entire special sheep equipment. Other items such as sheep bells, wool cards, hand clippers, and clipping machines may be included, also a dipping tank and the necessary dip, although several of these items would probably be regarded as major equipment. It is frequently hard to distinguish between the large and small items, but the aim is here to present only the multitude of miscellaneous articles the need for which would not naturally occur to one in the organization of the farm.

The most necessary article used in connection with swine seems to be the ring plier, and the accompanying box of rings. The small portable hog houses might be classed as miscellaneous equipment, and they are of frequent occurrence in the inventories. A snout clipper, tongs, pig forceps, and pig extractors are sometimes useful.

As a rule the poultry equipment on the general farm is confined to a very few items, and on many no special purchases have been made. Where incubators and brooders are bought a number of useful articles are usually included, and it is only occasionally that additional equipment is purchased. There are, of course, many items which would be found in connection with the specialized poultry farm which are omitted, as well as some which should probably be found oftener on general farms.

Bees are classed as livestock for want of a better designation, and where bees are found on the farms there are usually found a number of special items of minor value. Portable houses for storing bees throughout the winter are found in only a few cases and may be listed with the items of major equipment. The various items of bee equipment are illustrated and their use described in *Farmers' Bulletin* 59.

MISCELLANEOUS CROP EQUIPMENT

The small and miscellaneous equipment for the production and disposition of crops will include some items which pertain equally to several. These are hoes, baskets, shovels, forks, rakes, scythes, etc., but the class of all crop tools is usually small. In addition to the large machinery drawn or operated by horses each crop has several special items. The corn crop has for its special miscellaneous equipment usually a hand planter; a home made seed tester; a seed rack; several corn knives; and husking pegs, gloves or hooks; and frequently also such items as baskets, seed crates, ensilage forks, a seed corn grader, a shock tyer, and a horse for shocking. In cases where the ordinary wagon box is used for husking corn from the stalk a scoop board or patent end gate is a great convenience.

The small grains such as wheat, oats and barley, require certain special articles. A large number of grain sacks is probably the most frequent item in this regard. On many farms will be found the scythe or cradle, and occasionally a flail, the latter home made. A binder cover is a useful item, and is sometimes included in the purchase price of the binder. The scoop shovel, half bushel measure, a bushel basket, etc., may apply to small grains as well as to corn, potatoes, or other crops. A wooden hand rake is frequently a great saver of grain in a field, and a long tined straw fork a great convenience in handling straw in the barn.

In fitting up the barn for convenience in handling hay there will be needed a track and carrier, the single or double harpoon fork, or hay slings, a number of pulleys, a seven-eighths to one inch hay rope, and the lighter half or five-eighths inch trip rope. Some of these items, once they are installed, are regarded as part of the barn fixtures, and left permanently in place. Others especially the ropes and forks, are frequently taken from place to place by tenants, and their frequent renewal justifies classifying them as miscellaneous equipment. Several pitchforks, a hay knife, a scythe and snath, a baled hay hook and a hand seeder are commonly used.

Where potatoes are grown commercially there are frequently a large number of potato boxes or crates, a potato fork, a hand planter and potato scoop. On one Ohio farm where sugar beets were grown the small items included several beet forks, beet hoes and topping knives. In some sections the production of maple sugar and syrup forms an important farm enterprise requiring special equipment. Each crop has a few peculiar items of equipment, and the term "general farm" is broad enough to include many enterprises. The

foregoing classes of equipment will, however, apply to the majority of general farms in the northern and western sections of the United States.

EXTENT OF MINOR EQUIPMENT

For the purpose of ascertaining how much of the miscellaneous equipment discussed would be necessary on general farms, the annual inventories on the farms of thirty-three cooperators in Ohio were made as complete as possible with respect to the minor items. These farms included one poultry, truck and general farm, one large horse farm, and a number on which dairying was the principal enterprise, yet none departed radically from the general type. The average size was a trifle less than 167 acres, and the average equipment, as nearly as it can be determined, is given in tabular form on pages 11 to 15 inclusive.

The table showing the summary of the minor equipment inventories must be studied closely in order to be of the greatest value. Not all the items listed are necessary for a satisfactory farm equipment, and on no farm was a complete list found. No farm combined all the enterprises represented, yet every item in the list was found on one or more of these farms, and a few others were omitted as being of extremely unusual character and unlikely to occur in many cases. Many items which might be called farm equipment because found in farm homes rather than those in town are not included, the aim being to present a suggestive list of miscellaneous farm tools, etc., for the convenience of the farm manager. The use of the various tools is not described, as only the more common have been included and local merchants are usually familiar with all the items listed.

The table is designed to show the relative importance of the various items and approximately what would be required for a complete equipment. The first column shows the percentage of the whole number of farms from which each article was reported in the inventories. It is probable that in many cases there should be a slight increase in the percentage shown, owing to failure to get all the articles on some of the farms. It is believed, however, to be relatively correct as between the different articles. In the second column is shown the average number of each article on the farms which report the same. In the third column is the number which the *inventories* suggest as approximately the average for a well equipped general farm under the conditions obtaining in Ohio. In making up this number it has been necessary to consider the percentage of farms reporting each article, the average number of articles per farm reporting and the same average for the whole number of farms. The suggested number is the nearest whole number to the

mean found between the two averages. For example, the T-handled wood auger is reported from twenty-two out of thirty-three farms, or 67 per cent. A total of 67 augers was found on these farms, or 3.04 per farm reporting, and 2.03 per farm for the whole number. The mean is 2.54 and the suggested number 3. With one or two exceptions no article is included in the third column, however, which was not reported from at least 20 percent of the farms and for which the average per farm, for the whole number of farms, was less than three-tenths. In this way consideration was given to the fact that on some farms certain items are not reported, and to the fact that on farms which do report the various items there are undoubtedly cases in which fewer articles than those found would be adequate. This last is certainly true since in many cases where several tools of a kind are kept, a part are old, and are retained simply for occasional use. The arbitrary basis given was adopted because it was found to mark quite accurately the dividing line between what was considered essential and non-essential by the owners of several well equipped farms. The column containing the number suggested is not necessarily a recommendation as to what will be urgently needed for a farm of average size and type, but it is indicative of the number of articles suggested by the inventory. By carefully considering the needs of the farm the manager can cut down the list materially. The oil cans, wrenches, eveners, etc., purchased with machines were excluded, wherever practicable, from the inventories, hence the suggested number is less in many cases than the real total for such items.

In the fourth column is given a figure for the first cost of the various articles, the price of all being included for reference, even though the the articles are not all recommended for use. The price for the complete article, for example, a tool with handle, is given in most cases. This price has been obtained wherever possible from hardware merchants located in sections from which the inventories are taken. The majority of hardware items were priced by one of the leading hardware merchants of Wayne County, Ohio. Other prices were obtained from Farmers' Bulletin 347. Still others were supplied by various farmers who had purchased or made similar items within a few months of the date of inventory. These prices will, of course, vary a great deal with the location of the purchaser and the quality of the goods. Regarding the latter, however, the point was emphasized in obtaining prices that average figures were wanted for the quality of goods usually purchased by farmers. These prices are merely suggestive and cannot in all cases be relied upon, for the reasons just mentioned.

The total cost of the various items suggested is extended in the fifth column. The total, which seems extremely large in comparison with the usual estimates is, however, not unreasonable if a rather complete inventory is desired. Taking the grand total inventory of items mentioned in this list for all the farms, using the prices given in column four, and dividing by thirty-three, the first cost for the average farm of 167 acres is found to be about \$190.00. The discrepancy between this figure and that for the suggested column may be due partly to incomplete inventories, but more to the fact that the latter contains a large number of single articles for which the mean spoken of on page 10 was a fraction greater than one-half and less than one. The suggested column indicates a rather complete outfit. Neither figure, however, includes any allowance for a stock of materials for the repair of equipment as given in Farmers' Bulletin 347. An expenditure of \$50.00 or more in this connection would save many trips to town for materials, even if the equipment for making use of them were complete. Many items considered useful and necessary might be added to the list in the suggested column, but the purpose of this circular is to establish what might be called a working basis for considering this phase of equipment. The occasional need for many of these omitted items will be apparent and attention is called to the fact that the list in column three contains only 158 out of 240 articles, all of which were considered necessary in certain cases. The initial expense, if all the items were included in the quantity shown in column 2 would be over \$685.00, and it is not an uncommon thing to find farms in the United States on which the actual investment in small and miscellaneous items would be above this figure if all the tools had been bought first hand. The summary of the thirty-three inventories is given as follows:

SUMMARY OF INVENTORIES

Items	Per cent farms reporting	Average per farm reporting	Number suggested	Cost	Total	Inventory*	
						Number	Price of each
General Purpose:							
1 Auger.....	67	3 0	3	\$.25	\$.75	.....	1
2 Awl.....	27	1 9	1	.10	.10	.....	2
3 Axe and handle.....	88	2 1	2	1.25	2.50	.....	3
4 Pinch bar.....	64	1 1	1	.75	.75	.....	4
5 Bench screw.....	55	1 0	1	.60	.60	.....	5
6 Auger bit.....	94	6 7	7	.30	2.00	.....	6
7 Bit brace.....	94	1 2	1	1.50	1.50	.....	7
8 Steel square.....	85	1 1	1	.75	.75	.....	8
9 Bevel square.....	35	1 0	1	.40	.40	.....	9
10 Try square.....	25	1 0	1	.25	.25	.....	10
11 Wood chisel.....	73	4 3	4	.40	1.50	.....	11
12 Compass.....	42	1 0	1	.30	.30	.....	12
13 Level.....	64	1 2	1	.75	.75	.....	13
14 Drawing knife.....	91	1 3	1	.75	.75	.....	14

* These columns have been inserted to assist persons interested in taking an inventory of their own farms as mentioned on page 2.

SUMMARY OF INVENTORIES—Continued

Items	Per cent farms reporting	Average per farm reporting	Number suggested	Cost	Total	Inventory	
						Number	Price of each
General purpose—Continued							
15 Scratch gauge.....	45	1.4	1	\$.40	\$.40		15
16 Gimlet bits.....	55	3.0	2	.20	.40		16
17 Grub hoe.....	21	1.1	..	.50	..		17
18 Claw hammer.....	82	1.3	1	.50	.50		18
19 Hand axe.....	36	1.0	1	.50	.50		19
20 Hatchet.....	70	1.4	1	.75	.75		20
21 Screw driver.....	67	1.7	1	.25	.25		21
22 Log chain.....	82	2.5	2	1.50	3.00		22
23 Wooden mallet.....	36	1.5	1	.25	.25		23
24 Mattock.....	79	1.4	1	.75	.75		24
25 Compass saw.....	42	1.0	1	.30	.30		25
26 Hand saw.....	94	1.7	2	1.25	2.50		26
27 Crosscut saw (large).....	85	1.2	1	3.00	3.00		27
28 Plane.....	73	2.3	2	1.25	2.50		28
29 Iron wedge.....	79	2.5	2	.30	.60		29
30 Tape line.....	39	1.1	1	.50	.50		30
31 Rasp.....	39	1.1	1	.50	.50		31
32 Brush hook or scythe.....	21	1.0	..	1.25	..		32
33 Cant hook.....	42	1.4	1	1.25	1.25		33
34 Chalk line.....	27	1.0	1	.10	.10		34
35 Buck saw.....	10	1.0	..	.75	..		35
36 Carpenters' pinchers.....	30	1.2	1	.60	.60		36
37 Anvil.....	21	1.0	..	10.00	..		37
38 Vise.....	15	1.2	..	5.50	..		38
39 Forge.....	3	1.0	..	16.00	..		39
40 Combination drill press.....	23	1.0	1	4.00	4.00		40
41 Drills.....	27	3.9	4	.50	2.00		41
42 Timmers' snips.....	18	1.0	..	1.25	..		42
43 Cold chisel.....	73	2.3	2	.20	.40		43
44 Whetstone.....	24	1.8	1	.10	.10		44
45 Screwplate.....	27	1.0	1	10.00	10.00		45
46 Tongs.....	6	2.0	..	.50	..		46
47 Flat file.....	70	2.0	2	.15	.30		47
48 Round file.....	35	1.5	1	.30	.30		48
49 Taper file.....	42	2.2	2	.10	.20		49
50 Oil can.....	30	1.7	1	.10	.10		50
51 Machine oil (gals.).....	61	.8	1	.30	.30		51
52 Pipe wrench.....	24	1.3	4	1.50	1.50		52
53 Monkey wrench.....	64	2.1	2	.50	1.00		53
54 Tool grinder.....	30	1.0	1	3.00	3.00		54
55 Grindstone.....	91	1.0	1	4.00	4.00		55
56 Riveting hammer.....	39	1.5	1	.75	.75		56
57 Sledge hammer.....	33	1.1	1	1.00	1.00		57
58 Pliers.....	67	1.4	1	.50	.50		58
59 Nippers.....	52	1.5	1	1.00	1.00		59
60 Punch.....	33	2.2	2	.15	.30		60
61 Hack saw.....	18	1.0	..	.50	..		61
62 Saw set.....	36	1.0	1	.60	.60		62
63 Maul.....	16	1.0	..	.60	..		63
64 Post hole digger.....	41	1.5	1	1.25	1.25		64
65 Wire splicer.....	11	1.3	..	1.00	..		65
66 Wire stretcher.....	29	1.1	1	1.00	1.00		66
67 Ditch cleaner.....	22	1.0	1	1.25	1.25		67
68 Tile spade.....	31	1.6	1	1.00	1.00		68
69 Brick trowel.....	44	1.4	1	.40	.40		69
70 Plastering trowel.....	6	1.0	..	1.00	..		70
71 Sand sieve.....	16	1.4	..	.50	..		71
72 Pick.....	31	1.9	1	1.00	1.00		72
73 "D" handled shovel.....	31	1.4	1	1.00	1.00		73
74 Long handled shovel.....	13	1.3	..	1.00	..		74
75 Counter scale.....	16	1.0	..	5.00	..		75
76 Spring balance.....	34	1.1	1	.50	.50		76
77 Steelyards.....	28	1.1	1	2.00	2.00		77
78 Platform scale.....	38	1.0	1	8.00	8.00		78
79 Rat trap.....	24	1.0	1	.50	.50		79
80 Steel trap.....	26	2.1	1	.15	.15		80
81 Jackscrew.....	3	5.0	..	2.00	..		81
82 Step ladder.....	45	1.4	1	1.75	1.75		82
83 Ladder.....	52	1.4	1	2.00	2.00		83
84 Farm bell.....	58	1.0	1	2.00	2.00		84
85 Lantern.....	68	1.8	2	.90	1.80		85
86 Hoisting block.....	16	1.2	..	2.00	..		86
87 Barrel.....	71	3.0	3	.75	2.25		87
88 Padlock.....	39	1.8	1	.40	.40		88

SUMMARY OF INVENTORIES—Continued

Items	Per cent farms reporting	Average per farm reporting	Number suggested	Cost	Total	Inventory	
						Number	Price of each
General purpose—Con.							
89 Paint brush.....	48	3.3	2	\$.30	\$.60	.....	89
90 Whitewash brush.....	26	1.4	1	.75	.75	.....	90
91 Basket.....	52	5.8	4	.30	1.20	.....	91
Household and farm:							
92 Lard press and sausage stuffer.....	45	1.0	1	5.50	5.50	.....	92
93 Sausage grinder.....	48	1.0	1	2.00	2.00	.....	93
94 Hog scraper.....	10	2.8	2	.10	.20	.....	94
95 Hog hook.....	29	1.1	1	.05	.05	.....	95
96 Butcher knife.....	52	2.4	2	.30	.60	.....	96
97 Kettle.....	55	1.7	1	2.50	2.50	.....	97
98 Tree pruner.....	15	1.2	..	1 .50	.....	.....	98
99 Pruning shears.....	39	1.3	1	.40	.40	.....	99
100 Crates.....	39	54.7	40	.40	16.00	.....	100
101 Garden rake.....	64	1.2	1	.50	.50	.....	101
102 Hoe.....	88	2.4	2	.40	.80	.....	102
103 Cultivator.....	12	1.3	..	4.00	.....	.....	103
104 Trowel.....	12	1.3	..	.25	.....	.....	104
105 Cold frame.....	3	8.0	..	2.50	.....	.....	105
106 Flat.....	3	3.0	..	.10	.....	.....	106
107 Spade.....	36	1.4	1	.75	.75	.....	107
108 Sprinkler.....	21	1.1	..	.50	.....	.....	108
109 Lawn mower.....	64	1.0	1	4.00	4.00	.....	109
110 Lawn rake.....	21	1.0	..	.40	.....	.....	110
All stock:							
111 Broom.....	9	2.0	..	.30	.....	.....	111
112 Clipping machine.....	15	1.0	..	6.00	.....	.....	112
113 Manure fork.....	42	2.6	2	.70	1.40	.....	113
114 Pail.....	27	4.4	3	.15	.45	.....	114
115 Tie chain.....	18	5.3	3	.25	.75	.....	115
116 Tie rope.....	9	2.3	..	.25	.....	.....	116
117 Hand sprayer.....	12	1.0	..	.75	.....	.....	117
118 Wheelbarrow.....	42	1.4	1	4.00	4.00	.....	118
Horse and driving:							
119 Bit.....	40	2.4	2	.40	.80	.....	119
120 Blanket.....	91	2.8	3	2.00	6.00	.....	120
121 Brush.....	89	2.0	2	.50	1.00	.....	121
122 Currycomb.....	89	2.3	2	.25	.50	.....	122
123 Collar.....	43	2.7	2	3.00	6.00	.....	123
124 Harness oil (qts.).....	34	1.5	2	.25	.50	.....	124
125 Fly nets.....	34	2.8	2	1.00	2.00	.....	125
126 Halters.....	97	6.5	6	.75	4.50	.....	126
127 Muzzle.....	26	1.8	2	.20	.40	.....	127
128 Nosebag.....	14	1.4	..	.50	.....	.....	128
129 Sweat pad.....	37	2.2	2	.35	.70	.....	129
130 Harness punch.....	69	1.2	1	.50	.50	.....	130
131 Riveting machine.....	69	1.0	1	.50	.50	.....	131
132 Rivets (boxes).....	43	1.2	1	.10	.10	.....	132
133 Tie rope.....	81	2.8	2	.15	.30	.....	133
134 Saddle.....	57	1.0	1	10.00	10.00	.....	134
135 Riding bridle.....	23	1.3	1	1.00	1.00	.....	135
136 Snaps.....	23	7.4	4	.05	.20	.....	136
137 Sponge.....	14	2.0	1	.10	.10	.....	137
138 Neck straps.....	43	1.9	1	.75	.75	.....	138
139 Syringe.....	23	1.1	1	.60	.60	.....	139
140 Storm apron.....	17	1.2	1	.75	.75	.....	140
141 Buggy jack.....	40	1.1	1	.75	.75	.....	141
142 Wagon jack.....	14	1.0	..	1.00	.....	.....	142
143 Clevis.....	40	4.3	3	.10	.30	.....	143
144 Chamois skin.....	11	1.0	..	.50	.....	.....	144
145 Dust robe.....	62	1.2	1	1.00	1.00	.....	145
146 Lap robe.....	71	1.6	1	5.00	5.00	.....	146
147 Evener, 2-horse.....	60	2.0	2	1.50	3.00	.....	147
148 Evener, 3 or 4 horse.....	63	1.5	1	2.00	2.00	.....	148
149 Storm front.....	46	1.1	1	4.00	4.00	.....	149
150 Dash lantern.....	23	1.4	1	1.00	1.00	.....	150
151 Neck yoke.....	14	1.6	1	1.00	1.00	.....	151
152 Whiffle-tree.....	29	3.1	2	.30	.60	.....	152
153 Whip.....	60	1.4	1	.50	.50	.....	153
154 Whisk broom.....	11	1.0	..	.10	.....	.....	154
Cattle:							
155 Cow bell.....	6	1.5	..	.25	.....	.....	155
156 Calf muzzle.....	3	1.0	..	.20	.....	.....	156
157 Crate.....	3	1.0	..	.50	.....	.....	157
158 Tie rope or chain.....	39	3.9	3	.30	.90	.....	158
159 Dehorning clipper.....	9	1.0	..	5.00	.....	.....	159
160 Milk tube.....	15	1.0	..	.25	.....	.....	160

SUMMARY OF INVENTORIES—Continued

Items	Per cent farms reporting	Average per farm reporting	Number suggested	Cost	Total	Inventory	
						Number	Price of each
Dairy:							
161 Milk can.....	36	4.9	4	\$ 1.50	\$ 6.00	.....	161
162 Milk crock.....	27	9.9	7	.10	.70	.....	162
163 Milk pan.....	6	5.0	..	.20	.....	.....	163
164 Milk pail.....	70	3.2	3	.50	1.50	.....	164
165 Churn.....	45	1.1	1	4.00	4.00	.....	165
166 Butter crock.....	21	10.1	6	.20	1.20	.....	166
167 Butter bowl.....	21	1.0	..	.50	.....	.....	167
168 Butter scales.....	6	1.0	..	1.50	.....	.....	168
169 Strainer.....	30	1.0	1	.50	.50	.....	169
170 Skimmer.....	6	1.0	..	.10	.....	.....	170
171 Thermometer.....	24	1.0	1	.25	.25	.....	171
Sheep:							
172 Bell.....	12	5.0	3	.15	.45	.....	172
173 Shears.....	48	1.6	1	1.00	1.00	.....	173
Swine:							
174 Ring plier.....	58	1.1	1	.20	.20	.....	174
175 Rings (boxes).....	..	..	1	.10	.10	.....	175
176 Snout clipper.....	3	1.0	..	.40	.....	.....	176
177 Tongs.....	3	1.0	..	.50	.....	.....	177
178 Crate.....	15	2.0	..	1.00	.....	.....	178
179 Portable house.....	39	6.6	5	4.00	20.00	.....	179
Poultry:							
180 Fountain.....	6	3.5	..	.25	.....	.....	180
181 Feed hopper.....	3	3.0	..	.25	.....	.....	181
182 Trap nests.....	3	8.0	..	.25	.....	.....	182
183 Feed pan.....	3	6.0	..	.05	.....	.....	183
184 Feed sieve.....	3	1.0	..	.25	.....	.....	184
185 Hover box.....	3	6.0	..	.25	.....	.....	185
186 Egg tester.....	6	1.0	..	.15	.....	.....	186
187 Coop.....	3	3.0	..	3.00	.....	.....	187
188 Leg bands.....	6	50.5	..	.....	.....	.....	188
189 Bone cutter.....	6	1.0	..	6.00	.....	.....	189
Bees:							
190 Foundation (lbs.).....	6	6.0	..	.75	.....	.....	190
191 Section box (100).....	12	2.8	..	.75	.....	.....	191
192 Foundation fastener.....	9	1.0	..	.75	.....	.....	192
193 Hive.....	15	19.6	..	1.00	.....	.....	193
194 Super.....	12	30.3	..	1.00	.....	.....	194
195 Smoker.....	12	1.0	..	.50	.....	.....	195
196 Bee escape.....	6	2.0	..	.25	.....	.....	196
197 Bee veil.....	9	1.3	..	.10	.....	.....	197
198 Honey crate.....	6	13.5	..	.25	.....	.....	198
199 Honey extractor.....	6	1.0	..	3.50	.....	.....	199
Corn:							
200 Shock tyer.....	27	1.0	1	.50	.50	.....	200
201 Knife.....	70	2.7	2	.25	.50	.....	201
202 Hand planter.....	61	1.3	1	1.50	1.50	.....	202
203 Ensilage fork.....	6	1.0	..	1.00	.....	.....	203
204 Seed tester.....	42	1.5	1	.50	.50	.....	204
205 Seed rack.....	9	1.3	..	1.00	.....	.....	205
206 Husking peg.....	30	2.9	2	.10	.20	.....	206
207 Husking gloves (pr.)...	12	1.3	..	.75	.....	.....	207
Hay:							
208 Stack cover.....	3	2.0	..	8.00	.....	.....	208
209 Carrier.....	30	1.1	1	3.00	3.00	.....	209
210 Hoisting fork.....	58	1.1	1	1.25	1.25	.....	210
211 Pulleys.....	55	4.5	4	.40	1.60	.....	211
212 1-inch hay rope (ft.)...	61	132.5	110	.....	5.00	.....	212
213 ½-inch trip rope (ft.)...	30	65.0	40	.....	.45	.....	213
214 Hand fork.....	88	3.2	3	.60	1.80	.....	214
215 Baled hay hook.....	21	1.6	1	.30	.30	.....	215
216 Scythe and snath.....	88	1.4	1	1.25	1.25	.....	216
217 Hand seeder.....	70	1.1	1	5.00	5.00	.....	217
218 Sickle.....	32	1.1	1	.50	.50	.....	218
219 Slings.....	9	2.7	..	2.00	.....	.....	219
220 Knife.....	67	1.2	1	.75	.75	.....	220
Small grain & seed:							
221 Cradle.....	48	1.0	1	5.00	5.00	.....	221
222 Binder cover.....	36	1.0	1	3.00	3.00	.....	222
223 Flail.....	15	1.6	..	.....	.....	.....	223
224 Measure.....	33	1.4	1	.50	.50	.....	224
225 Straw fork.....	15	1.2	..	.70	.....	.....	225
226 Hand rake.....	36	1.3	1	.25	.25	.....	226
227 Sacks.....	97	38.6	38	.20	7.60	.....	227
228 Scoop shovel.....	82	1.7	2	1.00	2.00	.....	228

SUMMARY OF INVENTORIES—Continued

Items	Per cent farms reporting	Average per farm reporting	Number suggested	Cost	Total	Inventory	
						Number	Price of each
Sugar beets:							
229 Beet fork.....	3	2 0	..	\$1.50	\$....	.....	229
230 Beet hoe.....	3	6 0	..	.50	.....	.....	230
231 Beet topper.....	3	9.0	..	.25	.....	.....	231
Potatoes:							
232 Scoop.....	3	1.0	..	1.50	.....	.....	232
233 Fork or hook.....	39	1.4	1	1.50	1.50	.....	233
234 Hand planter.....	3	1.0	..	1.75	.....	.....	234
Maple sugar:							
235 Sap bucket.....	21	471.0	..	.20	.....	.....	235
236 Spout.....	15	485 0	..	.03	.....	.....	236
237 Cover.....	3	500 0	..	.06	.....	.....	237
238 Scoop.....	12	1.0	..	1 00	.....	.....	238
239 Gathering pail.....	12	2.5	..	.75	.....	.....	239
240 Tapping bit.....	9	2 0	..	.30	.....	.....	240
Total cost of items suggested.....					\$270.70	.....	.....

A careful study of the foregoing list will bring out many points worthy of consideration. To the owner of a farm who has no occasion from time to time to collect the miscellaneous equipment and take account of its extent, this study will probably suggest the advisability of taking an annual inventory of the small as well as the large equipment in order to keep track of his investment. The practice of taking an inventory even of the larger pieces of machinery, is not as common as it should be, and in many cases where an invoice is taken the "small stuff" is lumped in one item. During the process of taking the inventories used in compiling this circular the owner almost invariably expressed astonishment at the extent to which his capital was invested in miscellaneous articles. The tenant farmers, and especially those who have frequent occasion to move, will ordinarily be found better posted as to the extent of the miscellaneous equipment, and the equipment of the latter will usually be found to be much nearer the actual necessities than the equipment of the resident owner. To both of these classes, however, it is earnestly suggested that, following an inventory for the purpose of determining the number and the value of articles on hand there should be provision made for keeping track of the various articles in a systematic manner. Only in this way can loss through theft and carelessness be avoided; time saved through a knowledge of where the articles can be found when wanted; expense through duplication of item when the original article cannot be found for the time being be rendered unnecessary, and depreciation on account of neglect be reduced to a minimum. It is unnecessary to dwell upon these points, as they will be apparent to the business-like farmer.

This list is also suggested as containing possibilities of great value to the prospective farmer. To the average person the compiling of a complete list of articles necessary for use on the average sized general farm becomes almost an impossibility after he has listed the larger items such as machinery, wagons, etc. This applies as well to the man with some farm experience as to the one who engages in it for the first time. The experience of several men, born and raised on the farm and temporarily separated from it during a college course, will bear out this statement. One of these was actually in charge of an experimental farm for four years prior to taking up farming on his own account, yet his initial allowance for small tools and sundries was only \$25.00. After going over an incomplete list similar to the foregoing he purchased a very modest lot of small tools, amounting to over \$100.00 in value, from a local hardware dealer, thereby obtaining a cash discount of 10 per cent.

A recent graduate of the Ohio State University, before engaging in farming on his own account on a portion of his father's farm, kept in mind for four or five months the problem of getting a complete equipment within his means. He first noted all the items which he considered necessary, basing his list on his previous experience. His second step consisted of the task of obtaining the net retail prices of the various articles. The result was a total so large that the third and most difficult step—that of determining the actual necessities—was pursued diligently for a considerable time. Having finally reduced his list to the minimum he entered into negotiations with several of the local merchants. Two of these made special efforts to obtain his order and each made the suggestion that he take a trip at the merchant's expense to one of the cities in the state, and select his equipment from the large stocks in the wholesale supply houses. He accepted one of these offers, and, during the State Fair, spent a half day in a large warehouse selecting the style and quality of articles he desired. The goods were shipped to the local dealer, who obtained his profit and still made a cash discount of 10 per cent from the ordinary prices. The young farmer brought his entire stock of miscellaneous equipment from the store at one trip with a team and wagon, and then spent a day or two arranging his workshop and disposing of his various items in the most convenient places, the extent of his outlay impressing him with the necessity for taking systematic care of the smallest details. Several items which were not up to the standard were taken back and exchanged for perfect goods at the local store, hence the entire outfit was delivered at the farm with very little expendi-

ture of time and annoyance and in perfect condition. By following this method the farmer was enabled to make his selection from well known brands and from a larger stock than that afforded by the ordinary store, besides having a pleasant outing in connection. His total purchase amounted to \$125.00, a part being for household use. The following were charged against the farm business:

1 Leather halter.....	\$ 1.65	Brought forward.....	\$61.05
1 Gallon paint.....	1.50	1 Horse Blanket.....	3.00
1 Gallon barn paint.....	.85	1 Whip.....	.25
1 Bottle "3 in 1" oil.....	.10	1 Monkey wrench.....	.40
1 Smaltoil can.....	.05	1 Alligator wrench.....	.25
2 Leather punch.....	.60	1 Paint Brush.....	.15
1 Pair gloves.....	.20	1 Cahoon seed sower.....	4.50
1 Pair shucking gloves.....	.50	1 Saw set.....	.10
1 Shucking peg.....	.20	1 Log chain, 15 feet.....	1.72
1 Riveting machine.....	.50	1 Axe and handle.....	1.00
1 Soldering iron.....	.30	1 Boy Axe.....	.75
1 Crowbar, 16 pounds.....	.64	1 Cold chisel.....	.20
1 Center punch.....	.10	1 Chisel, 3-4 inch.....	.30
1 Draw knife.....	.60	1 Chisel, 1-inch.....	.35
1 Garden hoe.....	.35	1 Rope, 1-2 inch, 50 feet.....	.55
1 Grindstone.....	3.75	1 Hoisting block.....	2.50
1 Buggy robe.....	8.00	1 Tinner snips.....	.35
1 Blacksmith's vise, 5 inch.....	6.00	1 Road scraper.....	5.00
1 Tamper.....	1.00	1 Steel square.....	.85
1 Pair scales, 600 pounds.....	11.00	1 Nail hammer.....	.75
1 Oilstone.....	.50	1 Ball pein hammer.....	.75
2 Gallons of harness oil.....	2.00	1 Jack screw.....	2.25
1 Jack plane.....	2.00	1 Pipe wrench.....	1.50
1 Paint brush.....	.65	1 Currycomb.....	.20
1 Ratchet brace.....	1.75	3 Clevises.....	.24
1 Bit, 1-4 inch.....	.20	1 Crosscut saw and handle.....	2.80
1 Bit, 5-16 inch.....	.20	5 Files.....	.75
1 Bit, 7-16 inch.....	.20	1 Grub hoe.....	.45
1 Bit, 1-2 inch.....	.25	1 Garden hoe.....	.35
1 Bit, 10-16 inch.....	.30	1 Horse brush.....	.45
1 Bit, 12-16 inch.....	.30	1 Horse brush (tail).....	.15
1 Bit, 1 inch.....	.40	1 Hatchet.....	.75
1 Hand saw.....	1.75	1 Lantern.....	.90
1 Hand saw.....	.90	1 Fork, 4 prong.....	.60
1 Hack saw.....	.45	1 Punch.....	.10
1 Compass saw.....	.25	1 Pick and handle.....	.60
1 Pair of pliers.....	1.00	2 Boxes copper rivets.....	.20
1 Pair of pliers.....	.30	2 Boxes tubular rivets.....	.10
1 Post hole digger.....	1.25	1 Spade.....	.60
1 Screw driver.....	.35	1 Ditching spade.....	1.00
2 Shovels.....	1.20	1 Snath.....	.75
1 Scoop shovel.....	.75	1 Scythe.....	.75
1 Plastering trowel.....	.62	1 Wheelbarrow.....	1.75
2 Wedges.....	.40	1 Hay knife.....	.75
1 Fork, 3 prong.....	.65	1 Feed basket.....	.80
1 Whetstone.....	.05	1 Pair nippers.....	.75
1 Mail box.....	1.00	1 Sledge and handle.....	.90
1 Wagon jack.....	1.00	3 Quarts of paint.....	1.15
1 Bucket.....	.95		
1 Set ladder irons.....	1.35		
12 Bolts, 14-inch.....	.49		
Carried forward.....	\$61.05	Total.....	\$106.86
		Less 10 per cent cash discount.....	10.69
		Net cost.....	\$ 96.17

A similar course might well be pursued by many persons who are about to engage in general farming. As before stated, the saving through the merchant's discount is considerable. The merchant who furnished the majority of the prices contained in the tables stated that for a large bill of goods such as those under discussion, he could afford to give from ten to twenty per cent discount for cash on account of the size of the order and the saving in the cost of selling. This would pay interest on the investment for some years, to say nothing of the time which would be saved through having the stock complete at the beginning.

On nearly every farm some articles will be found which have been bought second hand, and perhaps others which have been acquired gratis with the place. No doubt a considerable saving may be effected by securing articles at odd times when work is not pressing. If, however, the business of the farm is stopped during attendance at a sale, it is an open question whether the saving on minor items over the suggested method will be sufficient to cover the time spent. As a rule these articles are summed up in the sale bill as "too numerous to mention" and no idea is given as to the extent or condition of the offering.

The lists given are in the nature of a census in that they present data from which the individual may secure the information suited to his own use. They are presented in that light, rather than as a recommendation of what should be purchased. Farmers' Bulletin 347, following a discussion of the various workshop tools, contains this paragraph:

"Shop Equipment:—The complete equipment of a shop for the making of general farm repairs should include the above blacksmithing outfit, the \$25.00 collection of wood-working and general-purpose tools, a pipe-working combination, miscellaneous tools, harness-repair outfit, a workbench, a pair of sawhorses, and a grindstone. This entire equipment for a shop can be secured for about \$100.00 in a fair quality of goods, and for \$150.00 tools of excellent quality can be obtained."

The great quantity of other general purpose items, together with those for use in connection with the producing enterprises, and the stock of materials needed for the repair of farm equipment, will easily bring the total cost of a good working equipment in miscellaneous articles up to \$250.00. The expenditure of this sum for this purpose in the organization of the farm is probably out of the question for many farmers, but due consideration at the outset for the necessary investment in minor items will save much inconvenience and disappointment later.

SUMMARY

Few farmers realize the extent of their investment in the small items of equipment or the time and inconvenience involved in buying numerous articles singly or in small lots. Before planning the farm equipment due consideration should be given to the necessary outlay for minor items, and, where possible, the latter should be secured at one purchase, thereby saving time, and usually money. The purchase of these articles in such a manner will mean a total expenditure sufficient to impress the farmer with the need for their systematic care. The minor items for a general farm of 160 acres in Ohio and other Middle Western states will probably cost from \$200.00 to \$300.00 by the time the equipment is complete.

Ohio Agricultural Experiment Station

CIRCULAR No. 99

WOOSTER, OHIO, MARCH 1, 1910

COOPERATIVE DAIRY WORK

Farm Management Investigations.

By L. H. GODDARD AND M. O. BUGBY

WHICH HERD REPRESENTS YOURS?

Herd No. 4			Herd No. 6		
Cow No.	Profit	Loss	Cow No.	Profit	Loss
1	\$ 22.91		1	\$ 60.09	
2	14.85		2	49.00	
3	2.79		3	48.89	
4		\$.73	4	47.43	
5		5.56	5	47.32	
6		7.81	6	38.43	
7		8.08	7	36.37	
8		8.74	8	34.02	
9		8.91	9	31.66	
10		11.96	10	26.25	
	<u>\$ 40.55</u>	<u>\$52.79</u>	11	24.43	
		40.55	12	12.57	
Total loss		\$12.24	Total profit	\$456.46	
Average loss per cow		\$ 1.22	Average profit per cow	\$ 38.04	\$ 00.00

How many dairy cows in Ohio are being kept at a profit? In order to study this question and other problems in connection with the dairy and to assist the dairymen of the State in answering it for their own herds, the Experiment Station* began in April, 1907, to loan scales, Babcock testers, etc., and to furnish the necessary blanks and supplies to dairymen on the condition that the following records of each cow be kept and sent to the Station each month: the daily weight of milk, a test of a 6-day composite sample of the milk

* As announced in Circular 67, Ohio Experiment Station.

and the approximate amount of feed used—the amount of feed to be determined by occasional weighings and accurate notes regarding changes in rations. From that time up to the present an increasing number of dairymen have been taking advantage of this opportunity until on February 1, 1910, eighty-one cooperators distributed throughout twenty-six counties of the state were keeping records of eleven hundred and seventy-eight cows.

DISTRIBUTION OF DAIRY COOPERATORS FEBRUARY 1, 1910

County	No. Cooperators	No Cows	County	No. Cooperators	No. Cows
Ashtabula	11	165	Lorain	2	20
Athens	1	8	Lucas	1	12
Belmont	1	16	Mahoning	2	13
Clermont	3	45	Medina	6	60
Columbiana	3	48	Meigs	2	21
Cuyahoga	1	20	Muskingum	2	33
Erie	1	13	Portage	13	179
Franklin	1	16	Seneca	1	13
Fairfield	1	10	Summit	2	32
Geauga	13	185	Stark	1	12
Harrison	1	22	Trumbull	6	130
Hamilton	1	7	Williams	1	25
Jefferson	1	25	Wayne	3	38
			Total—26	81	1178

Until August 1909, after the amount of milk and fat and value of product were computed and added to the original records, these original records were returned to the cooperator. Since that date the original records have been kept for the files of the Experiment Station and an adding machine copy of same returned to the cooperator each month, together with a statement showing the amount and value of milk, fat and feed, and profit over feed,—for each cow, for the whole herd and for the average of the herd.

At first an attempt was made to have the records begin and end with the calendar year, but this did not prove satisfactory, because of the varying lactation periods, of the different cows. At present the records are being kept by lactation periods, a loose-leaf sheet being devoted to each cow for each of these periods. As soon as the lactation period of any cow is complete the results are reduced to a yearly basis that they may be comparable with other cows of the same herd. This, of course, means that the records of the entire herd are never complete at the end of the first year, so a summary of the whole herd cannot be sent to the cooperator at that time, but with the monthly statements at hand he can easily pick out the unprofitable cows.

The fact that many cooperators are discarding their unprofitable cows makes it more difficult to determine the actual condition that existed before the records were kept. The Experiment Station cannot ask that a cow be kept in a cooperating herd after she has been proven to be unprofitable and as a result many of the poor cows do not complete the full year's record, thus making the average of the herd higher than it otherwise would have been. While the

records have not been continued long enough to permit as yet the showing of a distinct gain in many of the herds, it is manifest that such will be the case in the near future. In the herds of the 46 men who have kept the records for at least a year, less than 66 percent of the cows that were in the herds at the beginning are still retained while on the other hand the total number of cows in the herds has increased more than 5 percent. There were 538 cows in the herds when the records were commenced. There are now 566 cows in these same herds. Only 352 of this number were in them at the beginning. In all 789 cows have come under record in these herds within the period of study. This would indicate that the dairymen are getting rid of a large number of cows. Inasmuch as they now know which are the poorer ones, are the results difficult to predict?

On the following pages are given a year's summary of the records of each of six herds which have been in cooperation with the Station for more than a year. The records of some of the cows in these herds are the average of two years. These summaries are given simply to show conditions as they are existing in some of the herds of the State. The question may be raised as to whether the herds reporting to the Station represent the average of the State. We can unhesitatingly say that they do not. They are doubtless above the average. It may be assumed that dairymen who are willing to keep such records and to send them to the Experiment Station are not average. Nearly all of these men have been visited by a representative of the Experiment Station who finds that such is the case. There are often better herds in the community than those of the cooperators and in some instances the herds of the cooperators are about as poor as any in the community though the herd of the average man reporting is above the average of his community. Are the herds summarized on the following pages an average of those reporting to the Station? In answer we would point to the fact that the average pounds of butter fat produced per cow per year of all the cows whose records have been completed is 231.2, while the average of the six herds given is 235.4.

A word of explanation as to the method of arriving at results given in the following tables may be well. The *value of the product* was determined from the price actually received each month; i. e., it is the sum of the actual value of the products each month. This, with the difference in the season of freshening, will account for the fact that some cows which produced a smaller total product than others produced a greater total income. This in itself is a problem well worthy of consideration, but it must be left to a future publication. Whenever the whole product was not sold a valuation was placed on the skim milk or whey,—16 cents per hundred lbs. of

whole milk for skim milk and half as much for whey. The *cost of feed* was determined from the amounts and prices actually given by the dairymen. The "*net other costs*" (*) consists of depreciation, interest, taxes and insurance on the cow and equipment, veterinary bills and labor, less the value of the manure. These were determined as follows. The depreciation of the cow was based on the assumption that the average cow will be useful in the herd for six years and at the end of that time will be worth from \$25 to \$30. The value given by the owner was taken as the value on which all calculations were based. Interest, taxes and insurance were calculated at the rate of 6.6 percent of the average value of the cow. The interest, taxes, insurance and repairs on the building equipment were calculated at 8 percent of \$50,—the estimated average value of such equipment.

Spraying material, medicine and dairy utensils were calculated at the rate of 15 cents per thousand pounds of milk given. Labor was based on an estimate of \$17 for a cow producing 2,000 lbs. of milk and increased at the rate of 50 cents per each additional thousand pounds of milk produced. The manure value was calculated from the amounts of nitrogen, potash and phosphoric acid in the feed consumed, as indicated by average analyses. The valuation taken was 67 percent of that placed on these elements in tankage by the Ohio State Board of Agriculture. The following itemized "*net other costs*" of cow No. 7, Herd No. 5, valued at \$60.00, will illustrate the above.

Depreciation on cow.....	\$ 5.83
Interest, taxes and insurance on cow.....	2.23
Interest, taxes, insurance and repairs on buildings.....	4.00
Spraying material, medicine and dairy utensils.....	1.41
Labor.....	19.03
Total "other costs".....	\$ 33.50
Less value of manure.....	12.50
Net other costs.....	\$ 21.00

Plans are now under way to determine the actual investment per cow and the actual labor cost on the farm of each cooperator, as well as the difference in the sale value of each cow at the end of each lactation period, but the above figures are considered of more value for this preliminary report. The *actual profit or loss* given in the record shows the difference between the actual income and the total cost. The "*Elgin*" *profit or loss* in the last two columns is the difference between the total income, based on 27 cents for butter fat, less the total cost. This price may be considered average for most places in the State. It will be noted that nothing has been mentioned regarding the *value of the calf*. It has been assumed that the cow's share in the maintenance of a sire is about equal to the value of the average calf at birth. The best cows in a

* See Circular 134, Illinois Experiment Station.

herd would in most cases have calves of more value than this. Thus the difference between the best and the poorest cows might be much greater than that shown in the following tables.

HERD NO. I

Cow No	Milk	Fat	Fat	Pro- duct	Feed	Net Other	Total	Actual		Elgin	
								Profit	Loss	Profit	Loss
	Lbs.	Lbs.	%	Value	Cost	Costs	Cost				
1	6,113	331.7	5.42	\$117.53	\$52.04	\$16.78	\$68.82	\$48.71	\$.....	\$30.52	\$.....
2	5,970	280.9	4.70	102.02	38.02	20.70	58.72	43.30	.....	26.67	.....
3	5,824	251.4	4.32	91.54	52.04	16.59	68.63	22.91	.....	8.57	.....
4	3,759	191.7	5.10	70.79	38.24	16.32	54.56	16.23	.....	3.21	.....
5	3,469	199.1	5.74	72.69	42.65	14.98	57.63	15.06	.....	1.68	.....
6	4,523	202.8	4.48	75.28	45.21	16.26	61.47	13.81	.....	.52	.....
7	3,748	169.5	4.52	62.45	42.24	15.37	57.61	4.84	.....	.....	5.85
8	3,707	156.8	4.23	59.14	42.91	15.49	58.40	.74	.....	.....	10.13
9	2,439	140.9	5.77	49.14	35.69	16.19	51.88	.....	2.74	.....	9.94
10	3,407	148.5	4.36	52.55	42.84	15.38	58.22	.....	5.67	.....	12.67
11	4,088	163.8	4.00	58.42	49.58	15.20	64.78	.....	6.36	.....	14.01
Total	47,047	2237.1	....	\$811.55	\$481.46	\$179.26	\$660.72	\$165.60	\$14.77	\$71.17	\$52.60
Net	.....	.....	.....	.....	.....	.....	.....	\$150.83	.....	\$18.57	.....
Average	4,277	203.1	4.75	\$73.78	\$43.77	\$16.30	\$60.07	\$13.71	.....	\$1.69	.....

Herd No. 1 shows a difference of \$55.07 between the best and poorest cow. Had this herd consisted of three cows like the best one the net profit would have been near to the same, as shown above. The best half of the herd would have given about the same profit as the whole herd.

HERD NO. II

Cow No.	Milk	Fat	Fat	Pro- duct	Feed	Net Other	Total	Actual		Elgin	
								Profit	Loss	Profit	Loss
	Lbs.	Lbs.	%	Value	Cost	Costs	Cost				
1	7,313	226.1	3.09	\$93.22	\$48.98	\$16.28	\$65.26	\$27.96	\$.....	\$7.49	\$.....
2	6,188	194.7	3.14	71.09	41.19	15.24	56.43	14.66	.....	6.04	.....
3	6,350	203.9	3.21	71.55	44.11	14.07	58.18	13.37	.....	7.03	.....
4	6,602	201.1	3.05	73.81	44.23	16.40	60.63	13.18	.....	4.23	.....
5	6,097	223.0	3.66	69.58	52.93	12.71	65.64	3.94	.....	4.32	.....
6	5,710	177.6	3.11	60.14	40.22	17.23	57.45	2.69	.....	.....	.36
7	5,707	190.2	3.33	72.80	58.67	11.83	70.50	2.50	.....	.....	10.02
8	5,191	165.2	3.18	53.59	40.22	12.37	52.59	1.00	.....	.32	.....
9	5,228	187.8	3.59	56.48	45.42	14.20	59.62	.....	3.14	.....	.55
10	5,235	180.6	3.45	54.37	42.06	17.44	59.50	.....	5.13	.....	2.36
11	4,706	157.9	3.35	52.98	43.52	15.97	59.49	.....	6.51	.....	9.33
12	4,268	140.9	3.30	48.07	45.42	13.57	58.99	.....	10.92	.....	14.12
Total	68,595	224.9	.....	\$777.68	\$546.97	\$177.31	\$724.28	\$79.10	\$25.70	\$29.43	\$36.74
Net	.....	.....	.....	.....	.....	.....	.....	\$53.40	.....	.....	\$7.31
Average	5,716.0	187.4	3.28	\$64.81	\$45.58	\$14.78	\$60.36	\$4.45	.....	.....	\$.61

Herd No. 2 is above the average in its locality. The milk is sold to a cheese factory, which accounts for the difference between the "actual" and the "Elgin" profits. Had all the cows in the herd been like the best one, the owner would have made a profit of \$335.52, or about six and one-third times as much as he actually did make. Had he sold all of his cows except the best three he would have made a larger net profit. Had he sold the poorest third of his herd he would have cleared almost one-half more.

HERD NO. III

Cow No.	Milk	Fat	Fat	Pro- duct	Feed	Net Other	Total	Actual		Elgin	
								Profit	Loss	Profit	Loss
	Lbs.	Lbs.	%	Value	Cost	Costs	Cost				
1	5,773	272.4	4.72	\$ 78.76	\$ 28.90	\$ 19.30	\$ 48.20	\$ 30.56	\$..	\$ 34.59	\$..
2	5,155	202.4	3.93	57.79	28.11	23.30	51.41	6.38	...	11.49	....
3	4,854	186.8	3.85	58.47	29.26	25.56	54.82	3.65	1 ..	3.39	....
4	4,410	172.2	3.90	48.83	26.97	23.35	50.32	...	1.49	3.22	....
5	3,957	153.4	3.88	47.58	25.22	23.90	49.12	...	6.54	.....	1 37
6	3,938	136.5	3.47	44.65	25.47	25.76	51.23	...	13.58	...	8.07
7	3,269	113.7	3.48	43.07	28.33	27.97	56.30	...	14.23	...	20 38
8	2,450	91.6	3.74	26.66	24.80	16.55	41.35	...	7.69	...	12.70
Total	33,806	1329.0	...	\$405.81	\$217.06	\$185.69	\$402.75	\$ 40.59 37.53	\$ 37.53	\$ 52.69 42.52	\$ 42.52
Net	.....	.....	.....	.....	.....	.....	.....	\$ 3.06	.....	\$ 10.17	.....
Average	4,226	166.1	3.93	\$ 50.73	\$ 27.13	\$ 23.21	\$ 50.34	.. 38	.....	\$ 1.27	.....

Had the average cow of Herd No. 3 been as good as the best one the net profits would have been eighty times as great as they were. Had all the cows been sold but No. 1, the profits would still have been ten times as great. The young owner of this herd with 25 cows like the best one could make enough clear profit from the dairy alone on a rented farm in ten years to buy a 100-acre farm. It would take him eighty years to pay for the same farm from the profits of a herd of 250 cows no better than the average of his present herd.

HERD NO. IV

Cow No.	Milk	Fat	Fat	Pro- duct	Feed	Net Other	Total	Actual		Elgin	
								Profit	Loss	Profit	Loss
	Lbs.	Lbs.	%	Value	Cost	Costs	Cost				
1	7,269	267.3	3.68	\$ 83.37	\$ 42.16	\$ 19.30	\$ 61.46	\$ 21.91	\$	\$ 22.34	\$
2	5,806	201.9	3.48	71.99	40.61	16.53	57.14	14.85	.....	6.66	.....
3	4,764	196.9	4.13	58.31	38.45	17.07	55.52	2.79	.....	5.27	.....
4	5,175	175.6	3.39	55.66	41.41	14.98	56.39	.....	..73	.....	..70
5	5,406	174.1	3.22	53.34	40.53	18.37	58.90	.....	5.56	.....	3.24
6	4,120	140.4	3.41	41.84	36.49	13.16	49.65	.....	7.81	.....	5.15
7	3,867	148.4	3.84	43.51	36.23	15.36	51.59	.....	8.08	.....	5.33
8	4,048	155.1	3.83	45.98	40.71	14.01	54.72	.....	8.74	.....	6.37
9	5,242	159.8	3.05	50.09	43.05	15.94	58.99	.....	8.90	.....	7.46
10	3,478	113.1	3.25	36.16	36.21	11.91	48.12	.....	11.96	.....	12.02
Total	49,175	1732.6	.....	\$540.25	\$395.85	\$156.63	\$552.48	\$ 39.55	\$ 51.78 39.55	\$3 4.27	\$ 40.27 34.27
Net	.....	.....	.....	.....	.....	.....	.....	.....	\$ 12.23	.....	\$ 6.00
Average	4,918	173.3	3.52	\$ 54.03	\$ 39.59	\$ 15.66	\$ 55.25	.....	\$ 1.22	.....	\$ .60
11	7,643	283.7	3.71	97.05	55.10	11.94	67.04	\$ 30.01	.....	\$ 21.79	.....
12	9,580	297.9	3.11	103.94	56.56	12.74	69.30	34.64	.....	26.46	.....
Total	17,223	581.6	3.38	\$200.99	\$111.66	\$ 24.68	\$136.34	\$ 64.65	.....	\$ 48.25	.....

The record of Herd No. 4 began in April, 1908, and cows Nos. 11 and 12 did not enter the herd until December the same year, so the record of the first ten cows ends with March, 1909, and that of the last two with November, 1909. For this reason they have been computed separately. As the prices were somewhat higher the second year the "Elgin" profits are more comparable than the actual. We note that on this basis the herd of 10 cows lost their owner \$6.00, while the two cows purchased within the year gave a profit of \$48.25. These two cows were purchased of a neighbor

who had kept records for several years, so the purchaser knew exactly what kind of cows he was securing. Had the owner of Herd No. 4 sold all but the best three cows at the beginning of the year his profit would have been \$40.55 instead of a loss of \$12.24. However, the records up to date indicate that the second year's summary will be different from the first.

HERD NO. V

Cow No.	Milk	Fat	Fat	Pro- duct	Feed	Net Other	Total	Actual		Elgin	
								Profit	Loss	Profit	Loss
	Lbs.	Lbs.	%	Value	Cost	Costs	Cost				
1	6,456	353.6	5.47	\$125.81	\$ 42.06	\$ 22.53	\$ 64.59	\$ 61.22		\$ 41.21	
2	7,778	349.8	4.49	121.99	39.89	21.67	61.56	60.43		45.33	
3	6,693	339.0	5.06	120.67	42.06	20.90	62.96	57.71		39.28	
4	7,366	362.5	4.92	122.51	38.54	27.22	65.76	56.75		43.90	
5	6,809	318.1	4.67	109.64	39.83	19.98	59.81	49.83		36.97	
6	5,931	319.8	5.39	113.25	42.37	22.50	64.87	48.38		30.97	
7	6,077	307.8	5.06	103.90	35.85	21.00	56.85	47.05		35.98	
8	7,450	308.9	4.14	110.37	41.68	21.89	63.57	46.80		31.75	
9	5,838	299.2	5.12	99.55	33.35	23.09	56.44	43.01		33.68	
10	5,934	305.7	5.15	102.49	37.45	22.03	59.48	43.01		32.55	
11	4,718	256.8	5.44	92.37	31.45	19.53	50.98	41.39		25.90	
12	4,043	215.1	5.32	79.03	30.89	19.36	50.19	28.84		14.36	
13	3,603	195.2	5.42	71.80	30.89	17.94	48.83	22.97		9.64	
Total	78,696	3931.5	.....	1373.28	486.31	279.58	765.89	607.39		421.52	
Average	6,054	302.4	4.99	\$105.64	\$ 37.41	\$ 21.51	\$ 58.91	\$ 46.72		\$ 32.42	

HERD NO. VI

Cow No.	Milk	Fat	Fat	Pro- duct	Feed	Net Other	Total	Actual		Elgin	
								Profit	Loss	Profit	Loss
	Lbs.	Lbs.	%	Value	Cost	Costs	Cost				
1	\$ 6,929	\$ 425.0	\$ 6.13	\$124.21	\$ 43.05	\$ 21.07	\$ 64.12	\$ 60.09		\$ 61.73	
2	5,717	356.4	6.23	104.79	40.29	15.50	55.79	49.00		49.59	
3	6,738	391.6	5.81	112.37	42.83	20.65	63.48	48.89		53.03	
4	6,342	373.2	5.88	109.32	40.97	20.92	61.89	47.43		49.02	
5	7,076	383.6	5.42	113.15	48.92	16.91	65.83	47.32		49.06	
6	5,884	337.6	5.74	99.84	47.76	13.65	61.41	38.43		39.15	
7	6,558	323.0	4.92	94.73	39.58	18.78	58.36	36.37		39.34	
8	6,463	300.4	4.65	89.63	37.42	18.19	55.61	34.02		35.84	
9	5,645	290.0	5.14	82.70	35.50	15.54	51.04	31.66		36.29	
10	5,042	266.9	5.29	76.78	38.74	11.79	50.53	26.25		29.60	
11	7,257	385.2	3.93	84.11	49.20	10.48	59.68	24.43		28.93	
12	3,757	216.8	5.77	61.08	36.00	12.51	48.51	12.57		16.04	
Total	73,408	3949.7	.....	1152.71	500.26	195.99	696.25	456.46		487.62	
Average	6,117	329.1	5.38	\$ 96.06	\$ 41.69	\$ 16.33	\$ 58.02	\$ 38.04		\$ 40.63	

Herds Nos. 5 and 6 have no cows that made a loss and show that it is an easy possibility to have an entire herd which averages as good as the best cow in the first four herds. By eliminating the poorer cows and rearing calves only from the best ones, using a good sire from a known high-producing strain and by purchasing cows of known performance, the first four herds can easily be made to produce as great a net profit as the last two.

The evidence of the foregoing records seems to point to the conclusion that the average dairy cow in Ohio is not a very profitable animal, and that the average dairyman has in his herd cows which are not paying him. The question which is of vital importance to each dairyman of the State is not what the average cow or dairy is producing, but what his own dairy is producing.

It is not even enough that he know what his herd is averaging. He must know what each cow is producing. The only way to find out regarding this is by the proper use of scales and Babcock test. No money or time spent for the dairy will bring in larger net returns than that intelligently spent in keeping accurate records. The question is not whether the dairyman can afford to keep a record, but rather can he afford not to keep one.

One weighing and testing of the milk each year is not sufficient. It should be done at regular intervals; best, at least once each month. While very satisfactory results may be obtained by weighing and testing the milk of each cow once each month, the extra time necessary to weigh the milk each day will bring large returns. Aside from aiding in locating the poor cows in the herd, the daily record will give an added interest to the daily work of the dairy, claiming greater interest, better work and closer attention on the part of the hired labor, and most of all, will do much toward making better and more business-like dairymen of both the owner and his sons.

There are several ways in which these records may be kept,—

1. The dairyman may purchase an entire outfit himself. He can well afford to do so.

2. Several dairymen may club together and purchase an outfit, each doing his own testing.

3. A number of dairymen may organize a cow test association, and by paying a small amount per cow, hire a man to weigh and test the milk of each cow once each month. Several such associations have already been organized in the state and are accomplishing much good. If there is none in your locality, organize one. But if you are to receive the greatest benefit from it do not let the tester do all the work. Weigh your own milk each day.

4. Write to the Experiment Station regarding the loan of an outfit. In continuing its study of the dairy conditions and problems of the state the Experiment Station will continue to loan testing outfits, as it has done in the past, as long as funds are available for the work.

SUMMARY

- 1 A large number of dairymen in Ohio are not making a profit on a part or all of their cows.

- 2 This condition may be remedied by the continued and intelligent use of the scales and the Babcock test.

- 3 The Experiment Station will loan these outfits. Write for conditions and application blanks.

Address

OHIO EXPERIMENT STATION,

Wooster, Ohio.

546

Ohio Agricultural Experiment Station.

CIRCULAR No. 100

WOOSTER, OHIO, APRIL 7, 1910

THE CENTERS OF AGRICULTURAL PRODUCTION IN OHIO

By L. H. GODDARD

Where are the Centers of Agricultural Production in Ohio?

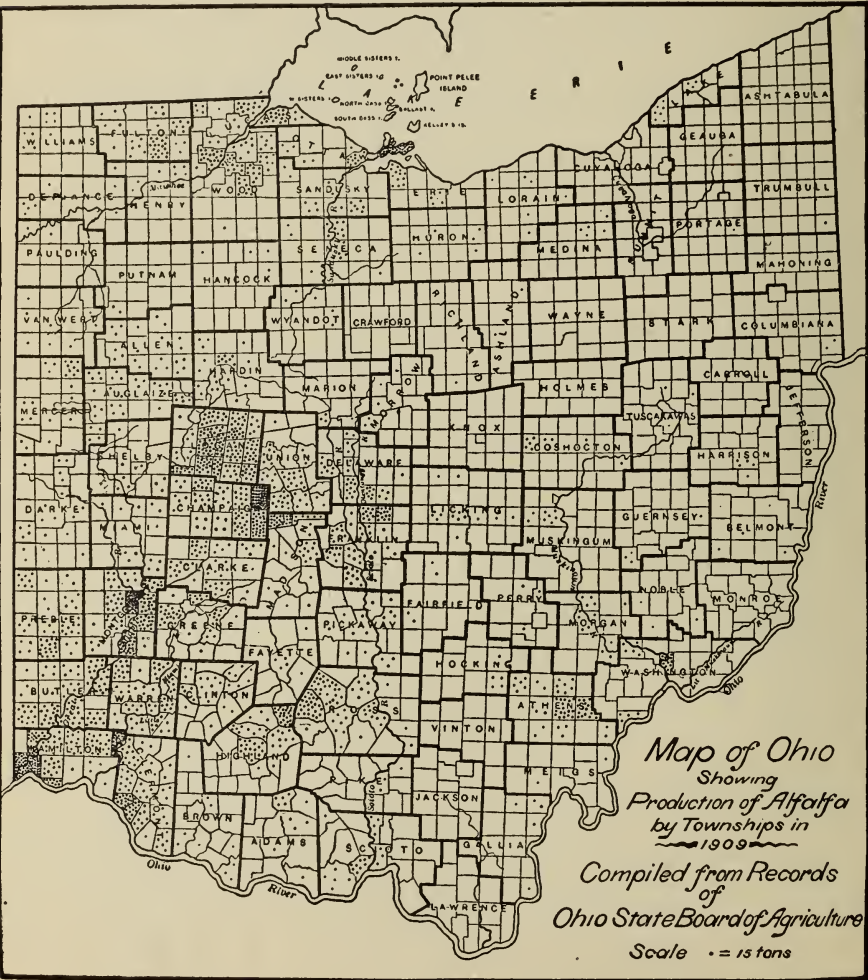
Why are they so Located?

Are they Spreading or are they Contracting?

Are New Centers Springing Up as the Years Go By?

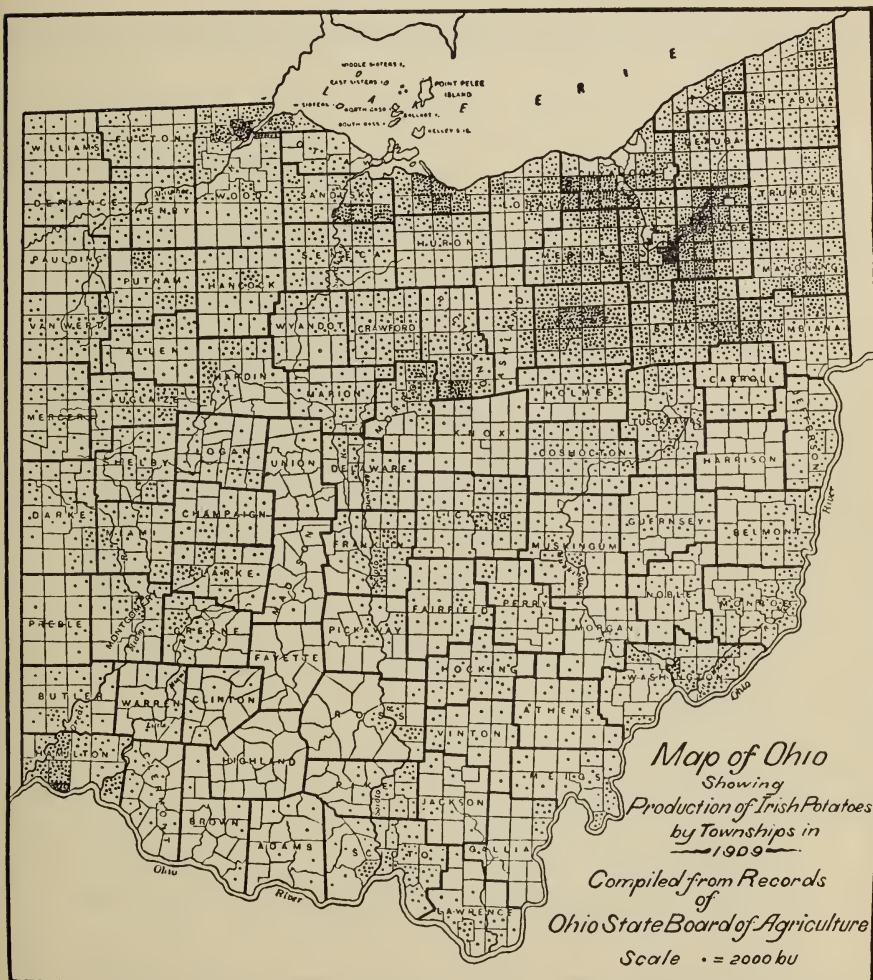
The day has come when progressive farmers wish to know in detail regarding the methods which successful farmers in other sections are following. This fact has long been true of the other professions, but until late years the conservatism of farmers has sufficed to keep them satisfied with the methods that have been handed down to them through several generations of their immediate ancestors. All this has changed now. In these days it is no uncommon experience to meet a farmer who is traveling throughout his State or into other States to observe the crops, livestock and farming methods that are in use on other farms. It is well that this is so. Money spent on such trips of inspection, providing they are well planned, is well spent. An important feature of the work of the Experiment Station is the study of the methods that are used by successful farmers. It is called "Farm Management Investigations."

The planning of these trips of inspection and investigation is not an easy matter. It is undoubtedly interesting and in many cases wise, to study the work of farmers who are successful largely because of their own personality, but in so doing it must be borne in mind that this personality cannot be copied. Unless a farmer is very sure of his own personal ability and resourcefulness in overcoming obstacles which he may meet, it is hardly advisable for him to undertake to follow a new method which he has observed in some other section unless a number of the more progressive farmers in that section have been so impressed with the desirability of the method that they have undertaken and have been able to

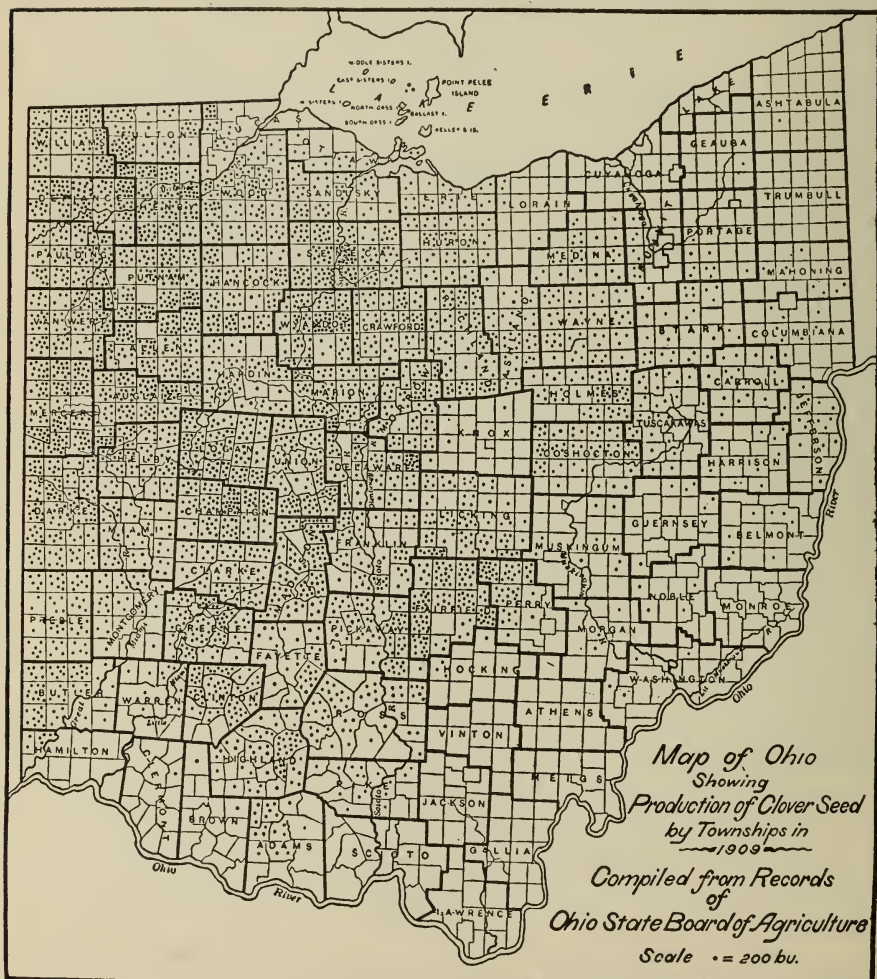


follow it successfully. When they have done this they will have formed a center of production. The more successful the method the more extensive this center of production will become.

In order to be able to find more quickly these centers of production of the various crops and farm products, the Experiment Station has prepared a number of maps on which are plotted graphically the agricultural statistics which are gathered by the township assessors, compiled by the county auditors and then turned over to the Secretary of the State Board of Agriculture. This opportunity is taken to thank the State Board of Agriculture for permission to prepare these maps from its records.

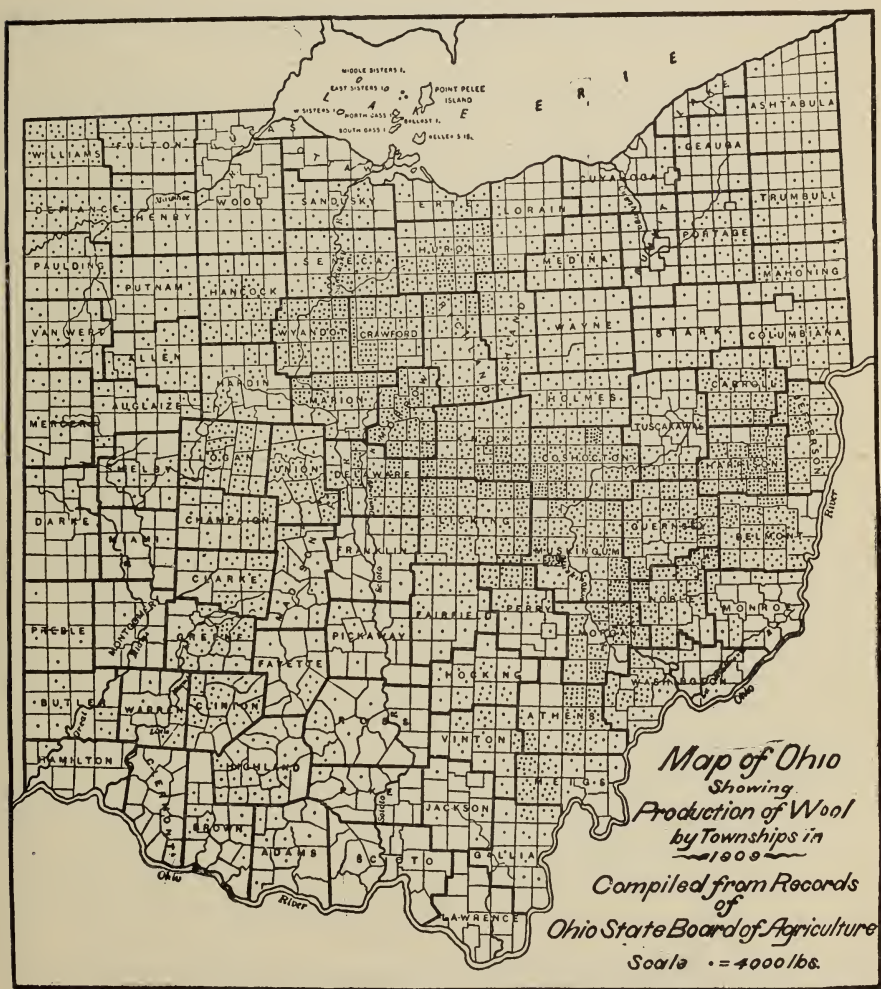


On the following pages are shown a few of these maps. In examining them it will be observed that each dot on the map represents a given number of pounds, bushels, gallons, tons, acres or individuals that were reported for the township on the map of which the dots are placed and that the greater the number of dots in the map of any township the greater the reported production of that township of the product in mind. On the other hand, it must be remembered that the entire absence of dots from the map of any township does not indicate that none of the crop was produced in that township, but that not enough of it was reported to entitle it to



a single dot. For instance, unless the report of a township shows more than 5,000 bushels of corn it would have no dot on the corn map. It should also be remembered that the maps in this circular were prepared from statistics gathered by the assessors in the spring of 1909 and represent in most cases 1908 production.

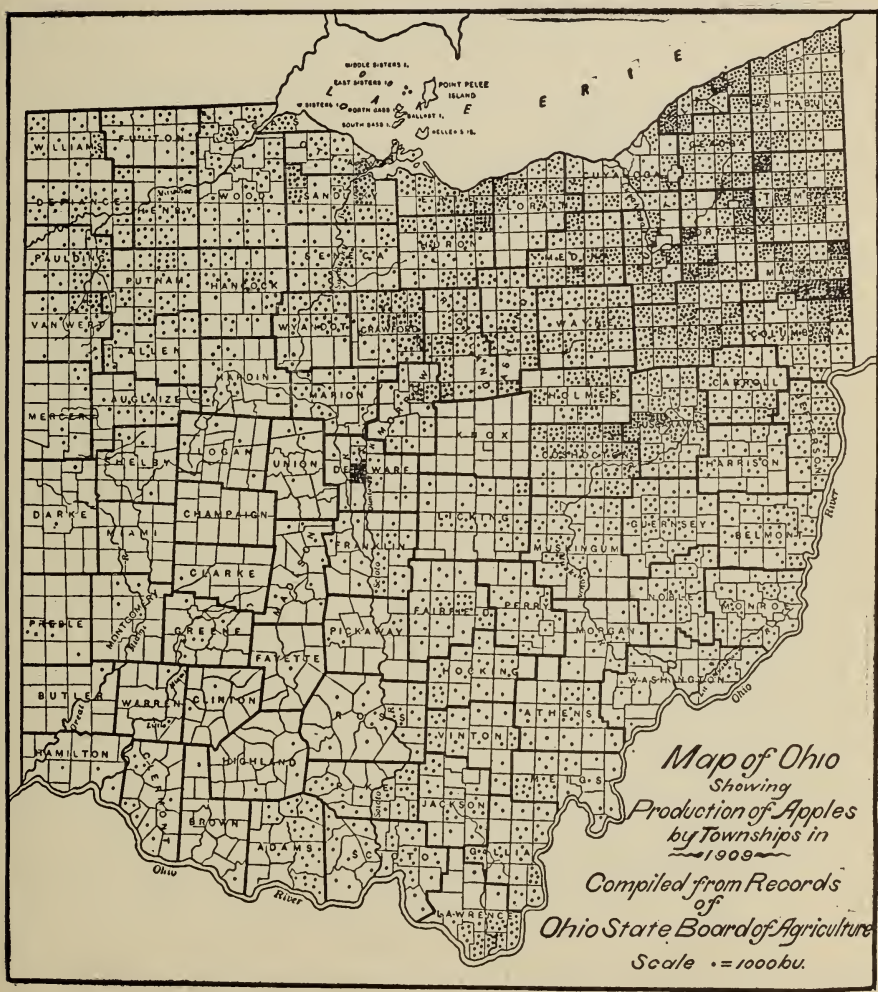
By an examination of these maps, what is meant by a center of production will become clear. For instance, the major center of production of tobacco is in parts of Darke, Miami, Preble, Montgomery and Warren counties. The minor centers are in Adams, Gallia, Noble and Belmont, Medina and Wayne counties. The map of oat production will show that according to these statistics the



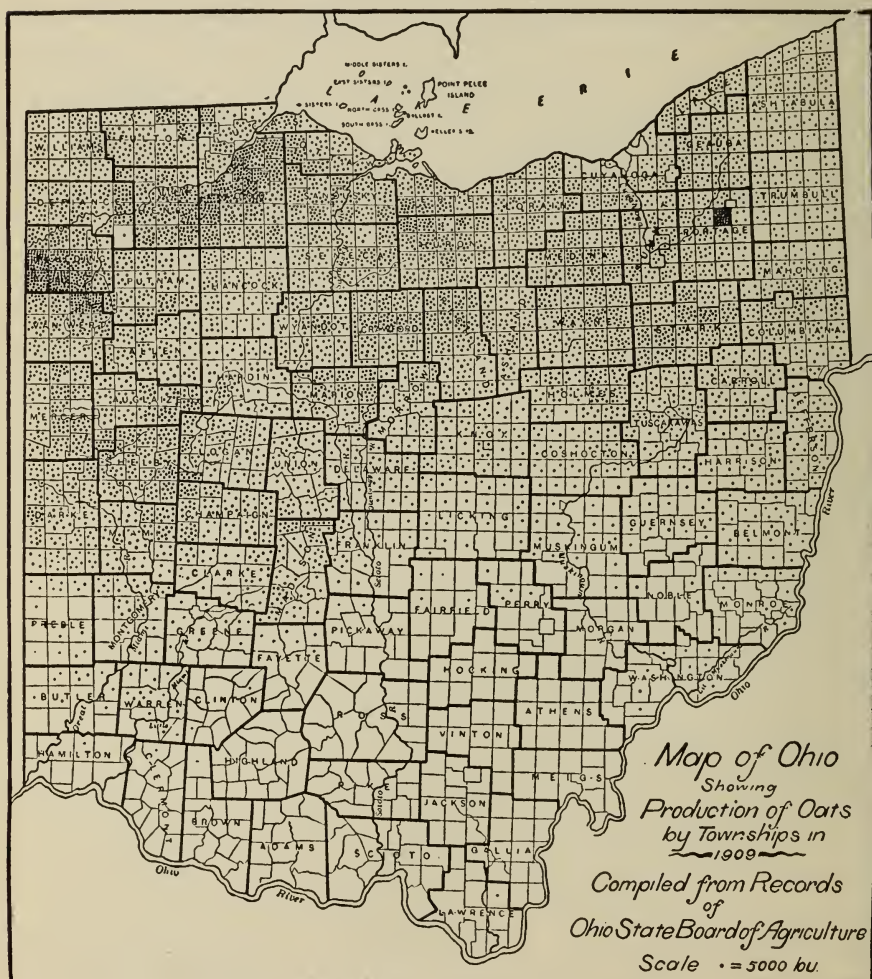
major part of the crop for the year mapped was produced pretty generally throughout the northern part of the State, with Paulding county as perhaps the greatest center of production. In Champaign and Logan counties on the alfalfa map will be seen a center which doubtless spread from a single pioneer alfalfa grower, other centers in connection with this crop having sprung up at a later date in other parts of the State. The center of apple production in the southern townships of Lawrence county illustrates what may be accomplished in the hills by a demonstration of a good method of apple growing.



A comparison of the maps for the year 1909 with those for the previous year has proven very interesting. With such crops as maple syrup, for instance, the centers of production have remained the same. With some other crops the variation has been slight, while in the case of clover seed, for instance, the maps for the two years are radically different. The study has not progressed far enough to produce certain evidence of the spreading of the centers of production of any of the newer crops or of the contracting of the centers of production of any of the crops. It will be manifest, however, that such spreading or contracting will become evident on these maps as soon as it does appear in the statistics.

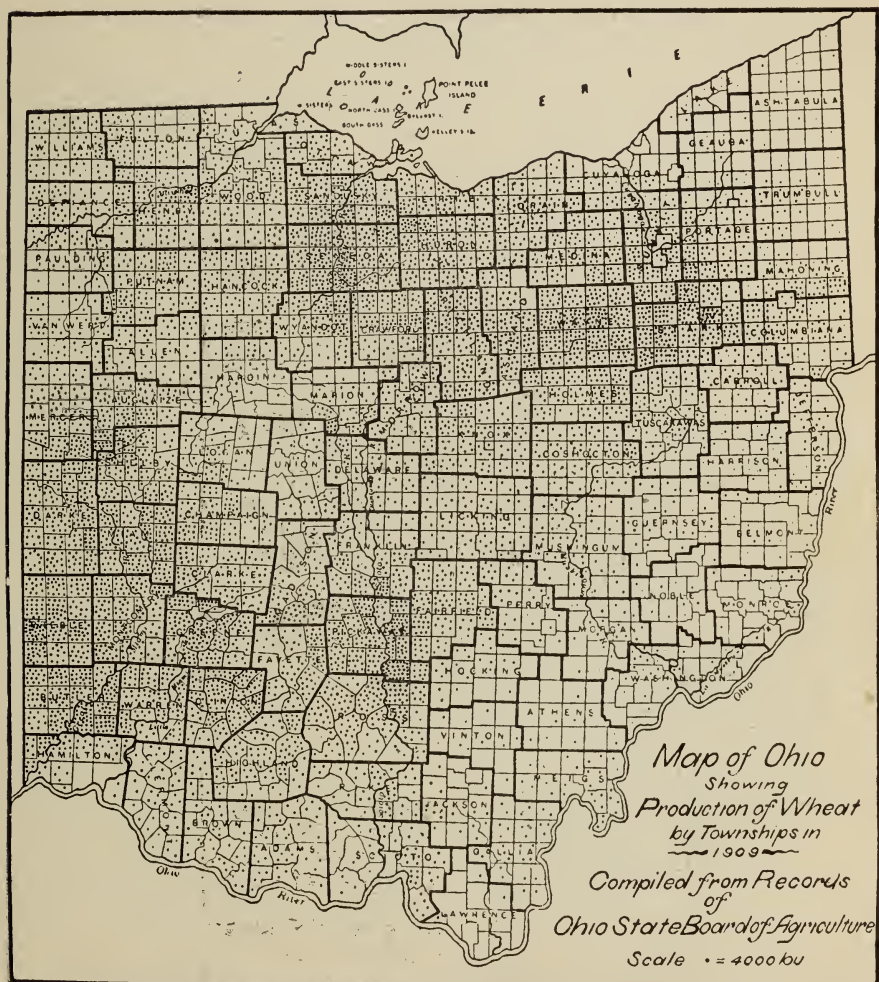


Even a hasty examination of these few sample maps will probably develop some surprises. Many will wonder, for instance, why the counties in the so-called wheat area of northern Ohio show no greater production of wheat than do some counties in southwestern Ohio; but if they were to see the maps showing the number of acres sown to wheat in the two areas, they would then realize that in the latter area the shorter rotation causes a greater acreage to be sown to wheat and a consequent greater total production of this crop per square mile in spite of the lower yield per acre. A great many people are disposed to question the accuracy of all statistics. It is

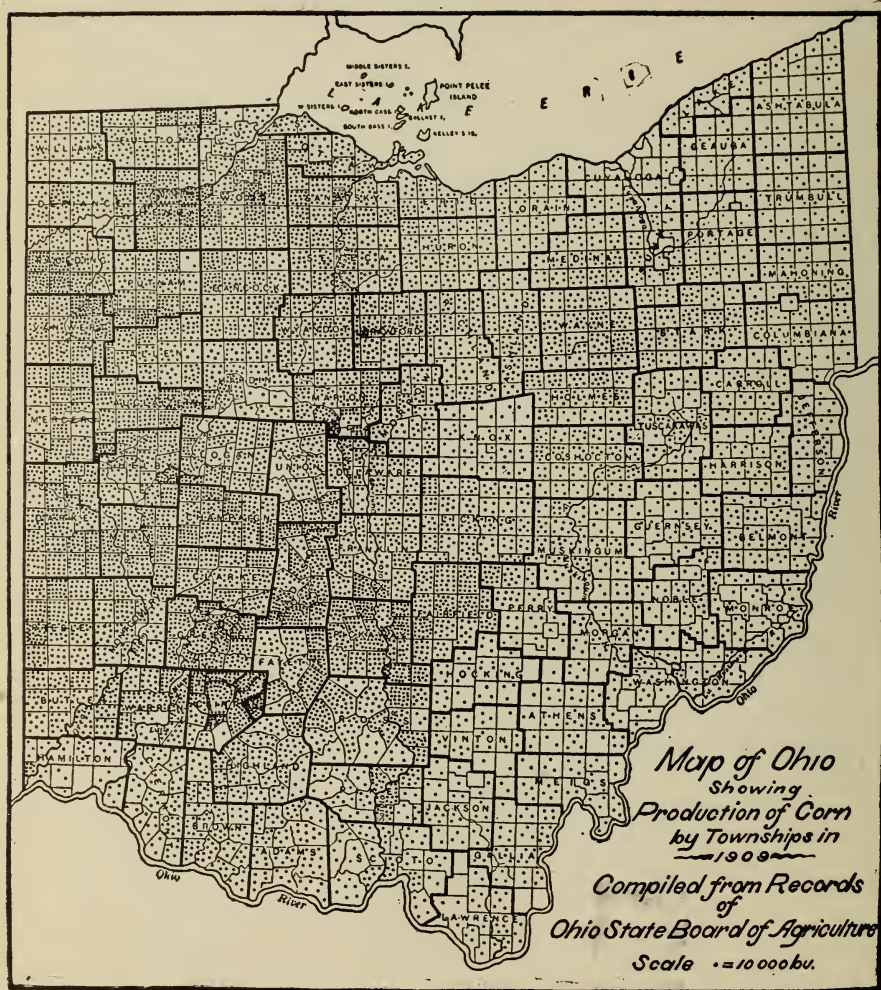


believed, however, that any thoughtful student of Ohio's production will finally decide that while minor errors in the statistics from which these maps were plotted may exist, they are not sufficient to affect seriously their value for use in comparisons of this kind.

The more careful observer may and probably will discover manifest errors which, in all probability, unfortunately do exist. For instance, for one of the very good townships of the State no report whatever regarding any crop has been made. In some other cases the indications have been very plain that in copying, the decimal points have not been placed where they belonged. In plot-

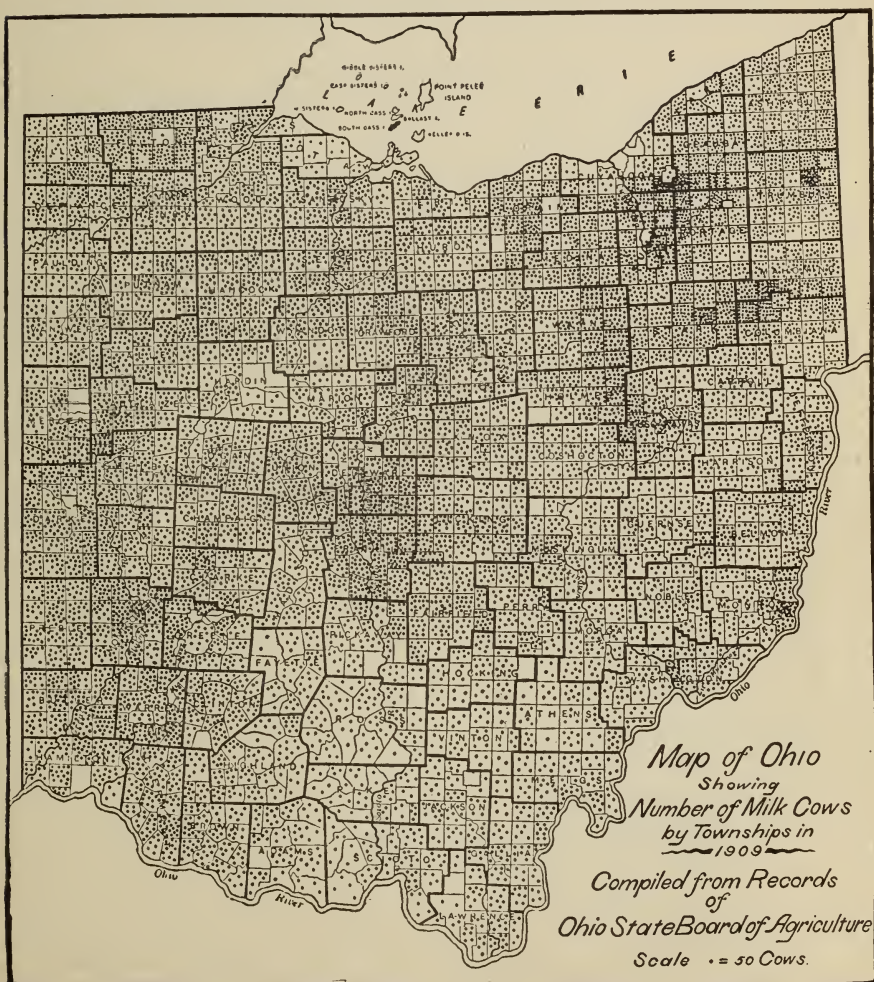


ting the maps for the year 1908, the effort was made to rectify these errors, so far as possible, but after some consideration it was decided to plot the 1909 figures just as they were returned, with the thought that if they were presented to the public in that way and especial attention was called to the value of such statistics, greater accuracy might be secured in the future. And since the year 1910 is census year, it was thought that this would be a very good year in which to make the start. It is well known that the United States Bureau of Census is making a special effort to have the agricultural statistics which they gather this year much more

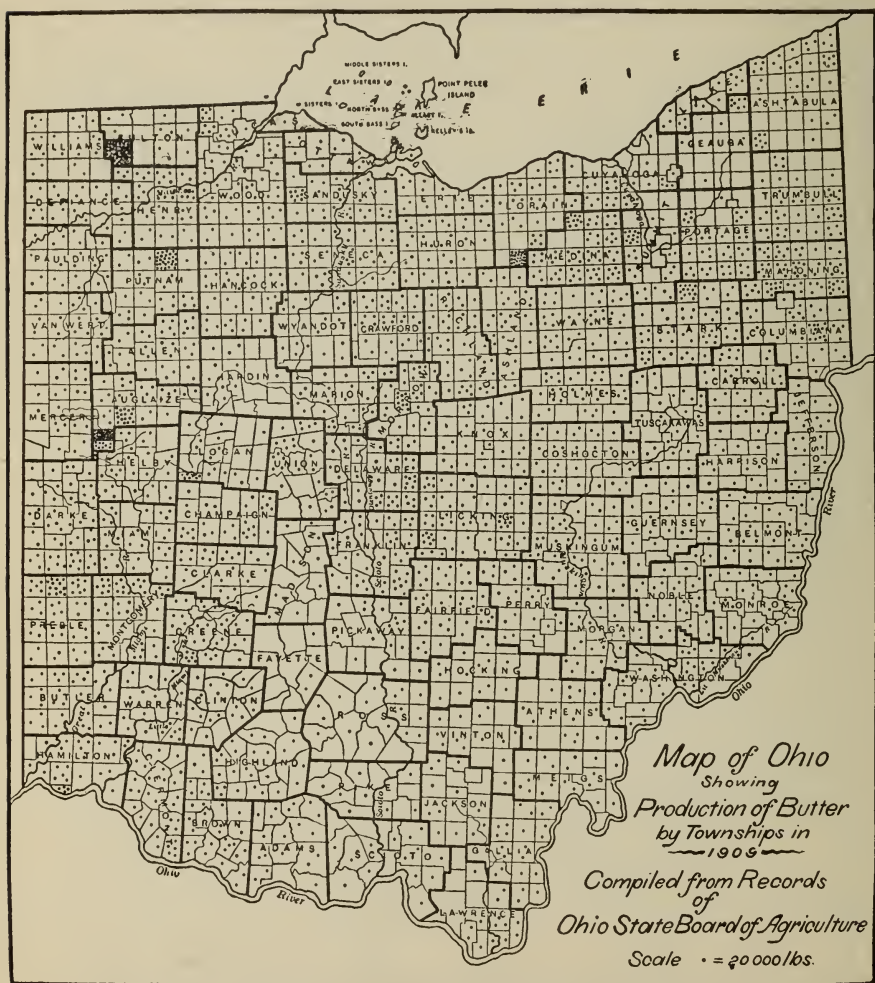


accurate than ever before. Why should not Ohio make an equal effort? And again, why should not Ohio's statistics for the year 1910 be as accurate as those of the Bureau of Census? The same people give information to both the assessors and the Census enumerators, and certainly the former should be just as accurate as are the latter.

Ordinarily, the Census returns are compiled by county only; whereas, as will be manifest from these maps, it is very important that the statistics shall be compiled by township. On almost every map striking variations within the boundaries of a number of counties, will be evident. In considering the possibility of using the

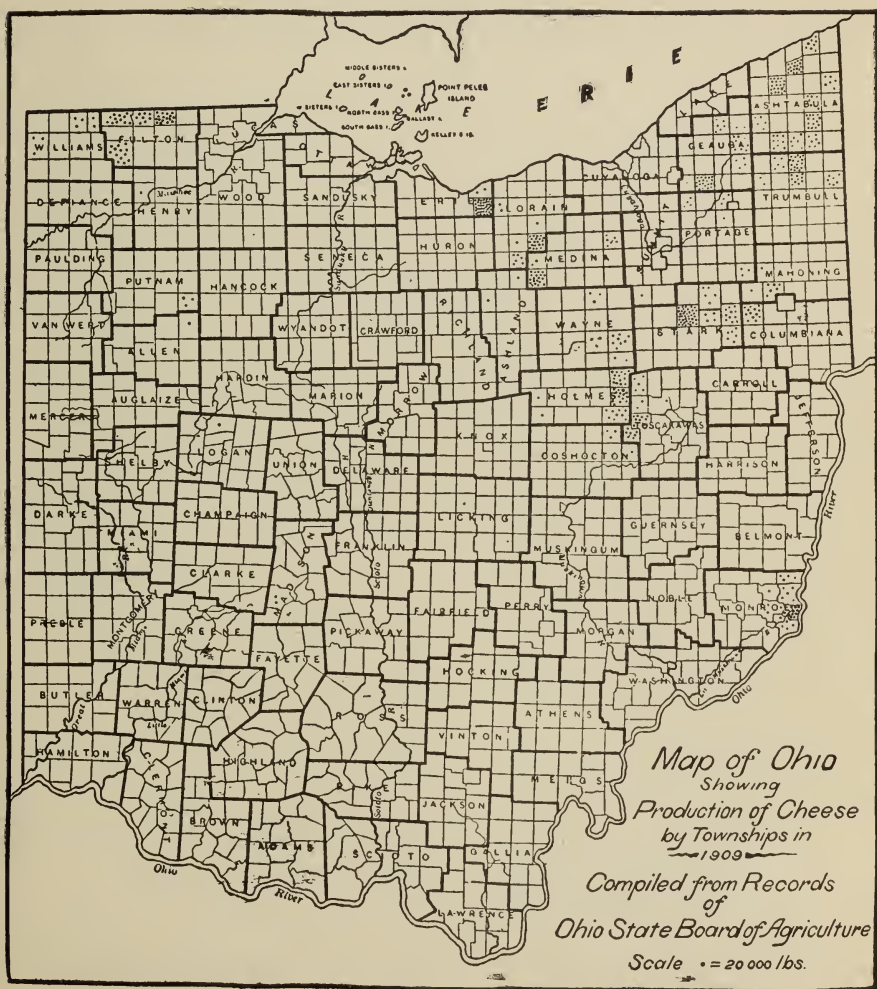


Census report, the Director of the Census was asked to make an estimate of the cost of compiling their statistics by township instead of by county. He accordingly had tabulated by township on their new tabulating machines the 1900 records of acreage and yield of the corn crop of Delaware county and, on the basis of time used for that tabulation, estimated that for the entire state it would cost extra for this township tabulation of the 1910 corn crop figures from \$125 to \$175. For some crops the tabulation would not cost so much but for others it might cost still more. He also advised that in order for them to be able to do it even at these prices, he must know of Ohio's desire before they take up the regular work.

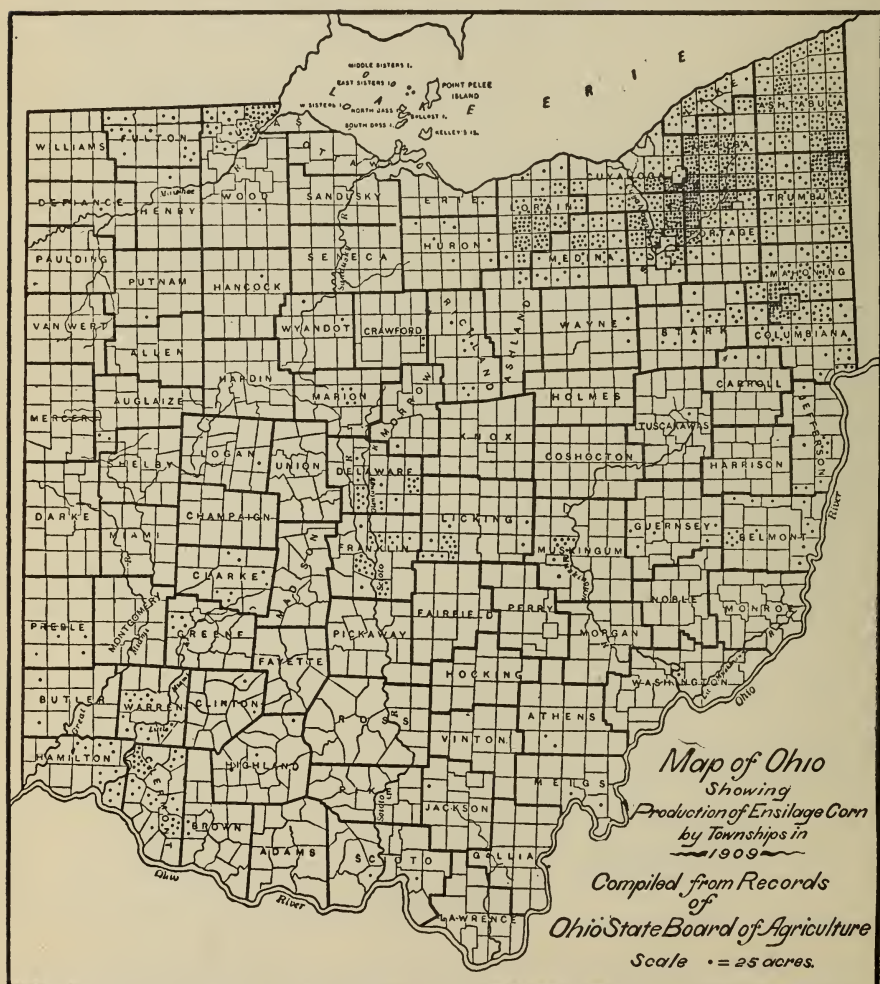


In the light of these figures and in view of the fact that yearly statistics are many-fold more valuable to Ohio than are decade statistics, is it not worth while for every auditor and every assessor in the State to undertake to have these Ohio statistics just as complete and just as accurate as the best? Certainly, if it is not worth doing in the best possible manner, it is not worth doing at all.

If the officers above mentioned will undertake to do their part the Experiment Station, on the other hand, will undertake to present the work to the people in connection with its Farm Management work, and through the still greater work, the Agricultural Survey of the State, which it hopes to undertake in the near future.



When the Ohio and Census statistics are both available, the Experiment Station proposes to compare them county by county and, if funds are available, to make arrangements with the Bureau of Census to tabulate their statistics of a single crop by township, in order that the comparison may be carried still further into detail. In letters of March 15th and 22d, 1910, the Director of the Census proposes cooperation with Ohio in learning wherein lie the causes of any variation which may exist between the Census and State statistics for this year. The auditor of one county has offered to assist in this comparison by making available for this purpose the original returns of the assessors of his county. Others will



doubtless be glad to do so likewise. There is no question but that all the auditors of the State have the welfare of the State at heart, and will do all in their power to promote it. The same could doubtless be said of the assessors.

The Experiment Station would therefore make a special appeal to the county auditors of Ohio to bring this matter to the attention of their assessors, in the hope that errors on their part may be avoided this year, and then to use the utmost care in making their own tabulations in order that when the work is complete we may all be proud of our State statistics.



Ohio Agricultural Experiment Station.

CIRCULAR No. 101

WOOSTER, OHIO, MAY 12, 1910

ILLUSTRATIVE EXHIBITS AT STATE AND COUNTY FAIRS

BY L. H. GODDARD AND W. A. LLOYD

A rational system of agriculture
cannot be founded without the
application of scientific principles.

—Leibig.



THE COUNTY FAIR: The social
climax of the rural year. It should
typify as well the progressive
agricultural spirit of the com-
munity.

FAIRS TO BE VISITED IN 1910

Exhibit will be open to the public on Wednesday and Thursday and
until noon Friday of each week.

COUNTY	TOWN	WEEK OF
Allen	Lima	September 5-10
Ashtabula	Jefferson	August 15-20
Athens	Athens	September 26-October 1
Auglaize	Wapakoneta	August 29-September 3
Belmont	St. Clairsville	September 19-24
Champaign	Urbana	August 22-27
Franklin	Ohio State Fair	September 5-10
Coshocton	Coshocton	October 10-15
Greene	Xenia	August 8-13
Guernsey	Washington	September 26-October 1
Hamilton	Carthage	August 15-20
Hancock	Findlay	September 12-17
Hardin	Kenton	August 22-27
Harrison	Cadiz	October 3-8
Lorain	Wellington	August 22-27
Lucas	Toledo	September 12-17
Marion	Marion	September 26-October 1
Medina	Medina	August 29-September 3
Mercer	Celina	August 15-20
Miami	Troy	September 19-24
Morrow	Mt. Gilead	October 3-8
Muskingum	Zanesville	September 12-17
Putnam	Ottawa	October 3-8
Scioto	Portsmouth	August 29-September 3
Seneca	Tiffin	September 5-10
Washington	Marietta	September 19-24

ILLUSTRATIVE EXHIBITS AT STATE AND COUNTY FAIRS



THE first agricultural fair in America was held at Pittsfield, Berkshire County, Massachusetts, in the year 1810. Elkanah Watson, a retired merchant from Albany, New York, instituted the fair and kept it going for a number of years. In 1815 Mr. Watson returned to Albany and organized the Albany Agricultural Society. In 1819 through his influence the New York legislature appropriated \$10,000 for promoting agriculture, and this appropriation was renewed annually for six years. In 1837 the State Agricultural Society was or-

ganized. The other states very rapidly followed the leadership of New York in the organization of Departments of Agriculture and Agricultural Societies.

The first bill to organize a State Board of Agriculture in Ohio was introduced by Hon. Almer Hegler, of Fayette County, in 1838. The Board was finally organized in 1844 and the first State Fair was held at Cincinnati in 1850. For a number of years the fair was rotated among different cities in the state: Cincinnati, Cleveland, Dayton, Newark, Sandusky, Zanesville, Toledo, Springfield and Mansfield each having one or more exhibitions. In 1874 it was located permanently at Columbus.

The early fairs were primarily agricultural, with an incidental commercial aspect. In the years following the Civil War many of the fairs became largely amusement aggregations with agriculture an incident or in some cases only a name. With the birth of the Agricultural College and Experiment Station there began a change in the character of the County Fair. The indirect influence of these institutions was first felt through the increased interest, stimulated by them, in improved livestock and better farm products. From this time the fairs began to return rather slowly to their original purpose. Some of the Colleges and Stations early saw an opportunity for educational and demonstrational exhibits at the fairs. As early as 1877 the Ohio College of Agriculture made exhibits at the State Fair. Soon after the organization of the Ohio Experiment Station in 1882 this work was taken up by it and has been continued almost every year since.

THE EARLY EXHIBITS OF THE EXPERIMENT STATION

The first exhibit made by the Experiment Station was at the Cotton States Exposition at New Orleans in 1883. This consisted of a collection of grains and grasses. The Station was represented at the Chicago World's Fair in 1893 by an exhibit in connection with the Office of Experiment Stations, United States Department of Agriculture. It was also represented at the Paris Exposition in 1900 in a similar manner.

The early exhibits at the Ohio State Fair consisted of samples of grain in the straw and in glass jars, with a small variety display of potatoes. The first time the Station made an exhibit at a county fair was at Wooster on September 22 and 23, 1891, after it had been decided to remove the Station to Wayne County. The exhibit was made under a tent about 12 by 20 feet in size. The same exhibit was made at a street fair at Doylestown on September 29th and 30th of the same year. An exhibit of much the same character was made at Orrville, October 11, 1893. With the growth of the Station and the addition of new Departments, the exhibit was somewhat enlarged, though it kept the same general character until 1905.

COUNTY EXHIBITS

The first visit to a county other than the one in which the Station is located was made when the exhibit was taken to the Stark County Fair at Canton, September, 1897. This was repeated in 1898. An exhibit was made at the Wayne County Fair in 1899 and again in 1902. Each year since that time until 1908 the Station has been represented in some way at the local fair. In 1909 it was decided that since the citizens of Wayne County had in the Station itself a permanent exhibit much more comprehensive in character than any that could be made at a county fair, and that, inasmuch as a most cordial invitation is always extended to any who care to visit the offices or fields of the Station, a greater duty to make county fair exhibits exists towards the counties which are more remote from the Station and whose access to it is not so easy. The Station made a small exhibit at the Preble County Fair at Eaton in 1904.

Beginning with 1905 the general policy of making exhibits at the county fairs was inaugurated. To help in paying transportation charges and other expenses incidental to moving and installing exhibits, \$30 was charged each agricultural society securing the exhibit. In this year the Station made exhibits at seven fairs, located in the counties of Summit, Cuyahoga, Fulton, Wood, Franklin, Clinton and Hamilton. The display was now somewhat enlarged. Features

showing the losses from waste of manure and gain from the application of fertilizers and manure under different methods of treatment were added. The illustration given below shows the exhibit as displayed at the Hamilton County Fair at Oakley in August, 1905. It illustrates fairly well the character and extent of the exhibits up to and including 1907. In 1906 the exhibit was further enlarged and was sent out under special shipping arrangements. Nine fairs were visited this year: the State, Preble, Richland, Geauga, Trumbull, Meigs, Putnam, Fairfield and Huron counties. In 1907 seven fairs were visited. Besides the State Fair an exhibit was made in Geauga, Trumbull, Richland, Putnam, Mercer and Huron counties.



The exhibit at the Hamilton County Fair (Oakley) 1905.

THE WORK SYSTEMATIZED

In 1908 the exhibit was considerably enlarged and made representative of the entire work of the Station. Eight counties were visited: Mercer, Darke, Franklin (State), Trumbull, Shelby, Butler, Stark and Wyandot.

Up to and including 1908 the matter of assignment of fairs to which the exhibit was to be sent had been governed entirely by priority of application. This had resulted in some counties receiving the exhibit year after year, while others failed to secure it at all because of delayed applications. It had also caused very long trips between fairs, and consequently the railroad transportation had

become a serious problem. Indeed, in 1907 in two cases the car containing the exhibit failed to arrive in time for it to be installed at the fair. To reach the eight fairs visited in 1908, it was necessary to cross and recross the state five times, the total distance traveled being more than 1600 miles. Moreover, applications for the exhibit were coming in from all parts of the state. Some system was therefore necessary to avoid similar if not greater difficulties in future years. To accomplish this end the Experiment Station proposed to the Fair Manager's Association a plan of cooperation in the matter of making assignments of fairs to which the exhibit should be sent. This plan was agreed to by the Association and a committee was appointed which took up the consideration of the applications for the exhibit for 1909. It was first decided by the committee that in selecting the fairs, no county should be included to which an exhibit had been sent in previous years.

To the earnestness and enthusiasm of this committee is largely due the increased appropriation made by the legislature for fair exhibit purposes, which appropriation made it possible to send out two exhibits in 1909. The saving in car mileage that came as a result of the work of this committee is clearly shown by a comparison of the mileage of the last two years.

In 1908, fairs visited 8, miles traveled 1604, miles per fair 200.

In 1909, fairs visited 20, miles traveled 2108, miles per fair 105.

Every detail of the route to be covered in 1909, and to a large extent in 1908, was worked out with the railroads months in advance, and every facility for the prompt handling of the cars containing the exhibit was made available by them. But for this kindness on their part disappointments by failure to arrive in time for installation of the exhibit, as in 1907, would probably have arisen in 1908.

Another matter, which had caused serious embarrassment in previous years, was the inadequacy of the space available for the exhibit at some of the fairs. Insufficient table room and wall space to properly display the exhibit, poor light and bad location on the fair grounds, had in many cases tended very greatly to lessen the influence of the exhibit. To overcome the inconvenience caused by this lack of systematic arrangement, every fair to which the exhibit was sent in 1908 was visited in advance by a representative of the Station and definite space arranged for. In arranging for the fairs to be covered in 1909, in connection with this advance work, a formal Memorandum of Understanding was signed with each Agricultural Society, in which was stated just what was expected of the Society and what would be done by the Experiment Station.

DESCRIPTION OF THE COUNTY EXHIBITS

The exhibits as sent out by the Station are purely illustrative in character. No competitive entries are made; no attempt is made to show fine products. The idea back of every feature of the exhibit is to show the result of an experiment. Only well established truths are shown; in most cases the average result of several years' work is given. Moreover, it is not such a display as can be seen profitably at a hasty glance. While each feature is so arranged as to make it a graphic presentation of some great truth, its chief value is in the many questions it suggests. The enthusiastic reception accorded the exhibit by farmers everywhere is one of the most encouraging signs of agricultural development.



These fellows help solve the problem of soil fertility on a well managed farm.

SOIL FERTILITY

The problem of restoration and conservation of soil fertility is one that arouses most intense interest and is of fundamental importance. It applies alike to the rich, fertile plains of the West, the thinner, more refractory soil of the Northeast and the steep, non-glaciated hillsides of the Southeast. Decreased yield, failure of clover, and barren hillsides have all sounded the alarm of soil depletion. It was not strange, therefore, that around the exhibit of the Department of Soils there was always to be found a group of interested men.

This exhibit told in a graphic way the increased yield from application of manure under different methods of treatment in a three-year rotation of corn, wheat and clover. Average results of twelve years' work were shown. This was done by means of a number of imitation bales of hay and sacks of corn and wheat so arranged as to show the exact amount of increase from manured plots over unfertilized plots. Results from the use of a complete commercial fertilizer, open yard manure, stall manure and stall manure treated with forty pounds acid phosphate per ton of manure, were shown. Large

cards giving complete details of the results of the experiment and the net value per acre of the increase in each case were so arranged as to make the experiment easily understood. A large banner with the legend "Will You Sell Manure at \$5.00 per Ton?" was very successful in attracting attention to this exhibit. It was shown by this illustration that results in excess of this amount have been obtained at the Station farm.

VALUE OF DIFFERENT KINDS OF MANURE

In close proximity to the above exhibit was that of the Department of Chemistry. In this was shown the fertilizing value of manure from the various farm animals. This was done by means of a number of glass tubes in which were the proportionate amounts of nitrogen, phosphoric acid and potash contained in the manure of the horse, cow, sheep and hog. In a similar way was shown the amount of lime, phosphorus, potassium and nitrogen removed by an average yield of corn, wheat, oats, potatoes, timothy hay, soybeans and clover.

FARM CROP EXHIBIT

In the exhibit of the Department of Agronomy there were shown sixty varieties of wheat and oats in the straw; samples of rye, emmer, barley and winter oats; a number of varieties of millet; the native American grasses—timothy, red top, blue grass and orchard grass, and the foreign grasses—rye grass, tall oat grass, brome grass and meadow fescue. There were also a number of the common legumes, including red, alsike and mammoth clover, alfalfa, soybeans, cowpeas, lupines, beggar weed, etc. The effect of early and late, and thick and thin seeding of oats and the average yield of twenty varieties of this crop were shown.

The corn breeding work was illustrated by showing several years' results with individual ears in ear-to-the-row work; one end of a rack showing by means of the height of the corn in glass tubes the yield of individual ears in the first year of the ear-to-the-row work, while in the other end was shown the results of crossing high-yielding ears, of inbreeding and of crossing low-yielding ears in multiplying plots. This department also had a number of interesting bromide enlargements of photographs showing alfalfa breeding work.



The effect of manure and fertilizer on farm crops is shown in this exhibit.



Exhibit showing varieties of wheat, oats, alfalfa, cowpeas, soybeans, etc.



A few bad weeds shown by the Department of Botany.



WEEDS have been described as “plants out of place”, and there are a large number of such plants which have long been considered as out of place on well-kept farms. The number of these seems to be constantly receiving additions from one source or another, so that the vigilant farmer must be ever on the aggressive in the long-continued warfare against these meddlesome enemies. Not only does weed growth be-

speak untidiness in husbandry, but it also consumes moisture and plant food which is needed by the more valuable plants. For these reasons the large display of pressed and mounted weeds shown by the Department of Botany was always a source of much interest. The broad leaf, the buckhorn, and the bracted plantain, the ox-eye daisy, wild carrot, yarrow, horse nettle, Canada thistle, mustard and many other dangerous weeds were shown. The Weed Manual describing the weeds and giving methods of combating them was much in demand. There were also exhibits showing plant diseases:—wheat scab, anthracnose, early and late potato blight, etc. At some fairs quite a large number of weeds were brought in by the farmers for identification. In many cases these could be found among the specimens shown; in others they were identified by some of the attendants, while in still other cases specimens were sent to the Experiment Station, by which the identification was made and sent to the inquirer. The intense interest everywhere manifested by the boys and girls in this exhibit, and in the butterflies, moths, bugs and insects of the Department of Entomology, indicates the readiness and willingness, so far as the children are concerned, to learn something of the common, everyday things of farm life.

Another feature of the work of the Department of Botany was an exhibit showing some of the more common adulterants of clover and grass seeds. While the United States Department of Agriculture, the Agricultural College, or the Experiment Station will gladly make purity tests of any of the farm seeds, it is advisable for the farmer to know for himself the more common adulterants. Beneath magnifying glasses were shown the dodder with the alfalfa seed, the plantain in the clover, and many others that the intelligent observer would afterwards recognize should they occur in commercial seed.



A bunch of money-makers.

ECONOMICAL FEEDING OF LIVE STOCK

Except in a very limited area of the state, livestock is an important factor in the farm equation. The intelligent use of feeds in a way to make the greatest and most economical gains will go a long way in putting the balance on the right side of the farm ledger. Among the features of the display of the Department of Animal Husbandry was an exhibit showing the value of corn in comparison with oats as a feed for horses doing regular daily work. This was shown by means of representative daily rations of corn and oats with mixed hay. In the experiment illustrated, one horse of each team in the test was fed a corn and one an oat ration, careful observations being made of each horse as to weight, spirit, endurance, etc. Rations for fattening range lambs were likewise shown. There was also an exhibit showing the value of silage in comparison with grain for dairy rations. One ration consisted of corn silage and clover hay with a small amount of grain; in the other the silage was displaced by corn meal, bran and oil meal. The amount of butter produced by one dollar's worth of these rations was illustrated by means of a representative exhibit showing the respective amounts of butter for the two rations. There was also an illustration of a pig-feeding experiment, showing the comparative value of corn, corn and middlings, corn and tankage and corn and skim milk as a ration for fattening swine. The value of these rations was exhibited so as to show the amount of each of the above feeds used for one day's feeding and the necessary amount for one pound gain. The daily gain per pig was shown by proportionate amounts of bacon.





HERE has arisen a host of insect and fungous enemies to hinder and destroy every plant, every grass and grain and fruit and flower that man has subjugated and improved and made to minister to his sense of the useful and beautiful. The slaughter of the birds that once

held these pests in check has left science to find artificial means of combating them. Not all insects, however, are harmful. In the exhibit of the Department of Entomology many specimens of both the beneficial and the injurious were shown. Not only were there beautiful mounted specimens of the adult insects, but also the life history of many of them was illustrated: the caterpillar, the chrysalis and the pupa in all stages of development. There were also exhibits showing the effect of the various scab and fungous diseases on fruit and forest trees; samples of various spray mixtures with the directions for application; the different nozzles used in spraying; a number of photographs illustrating the work in orchard, field and garden; small microscopes beneath which were mounted a number of common insects, and a large map of Ohio showing distribution of wheat joint worm in 1908 and 1909. A number of the best books on the subject, suitable for popular use, were available at all times for examination.

FORESTRY EXHIBIT

Ohio contains much land that nature probably intended should remain in perpetual forest. Much of the original growth was wasted, and nature's attempt to reforest has been arrested. Bleak and barren fields, gullied and washed hillsides, stand as witnesses of the fearful punishment that is exacted for this misappropriation of the gifts of the Creator. In every part of the state the available supply of timber for building material, for fuel and for posts is rapidly diminishing. To supply these farm wants and the increasing demands for railway cross-ties, telephone, telegraph and traction line poles, and to provide lumber for the future, makes the subject of forestry one of great practical and economic interest throughout the state.

The Forestry Department was represented by sections of catalpa trees showing total growth on one-eighth of an acre in nine years. There was also shown an entire catalpa tree nine years old, 36 ft. high and 16 inches in circumference. The effect of weed trees in the forest was shown by a block from a worthless beech with cross-sections from each tree of the scanty and comparatively valueless growth



Showing representative baskets of sprayed and unsprayed fruit from a cooperative orchard in Washington County.

found under its shade, in comparison with cross-sections from each tree growing on the same area immediately adjoining. Bromide enlargements of photographs showing forest conditions formed an interesting part of the display of this Department.

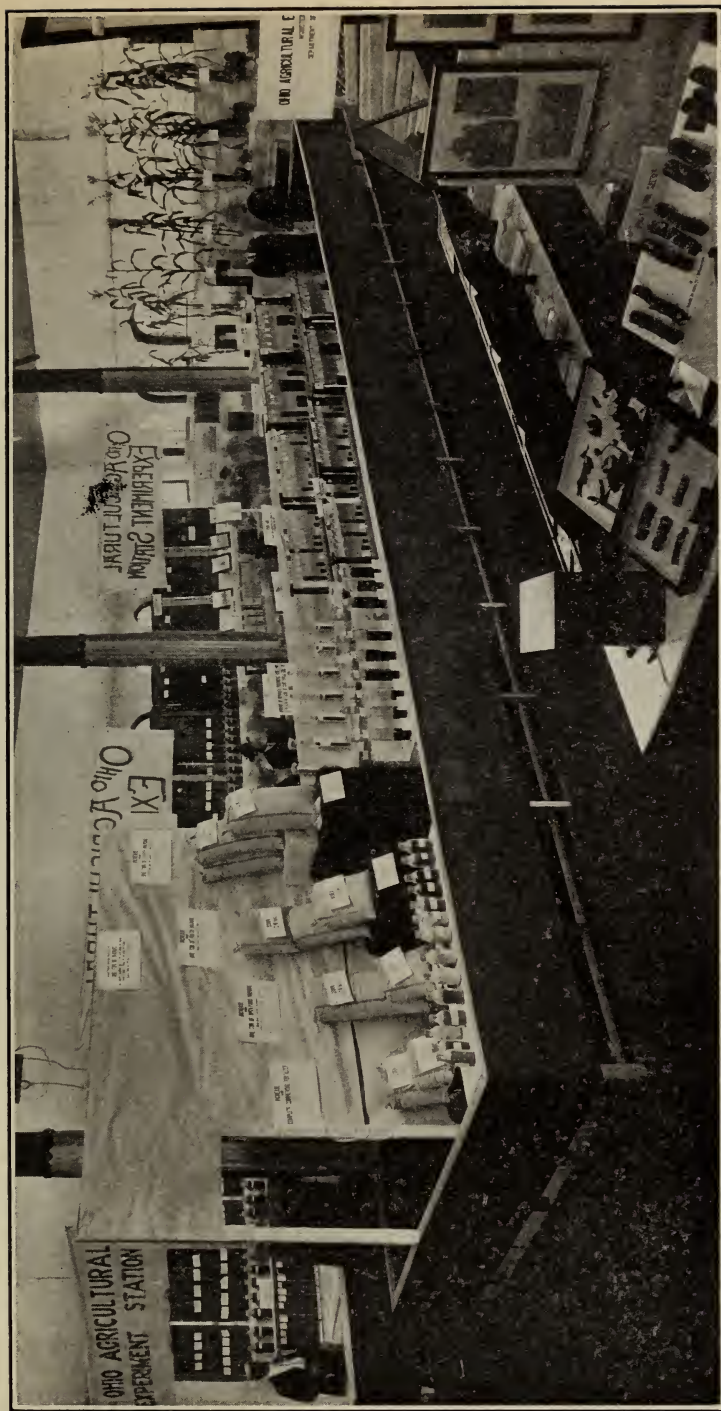
EXHIBIT SHOWING EFFECT OF SPRAYING

Some of the most valuable work of the Station is done in cooperation with farmers throughout the state. An illustration of this work was furnished by the Department of Horticulture. In the spring of 1909 this Department took charge of three orchards in Washington county which for a number of years had failed to produce profitable crops. This is a part of the state which had once grown beautiful fruit. The Station effectively sprayed these orchards throughout the season. The entire products of sprayed and unsprayed trees were shown and the striking differences both in quantity and quality of the sprayed and unsprayed fruit were such as to awaken much interest in scientific spraying of fruit trees.

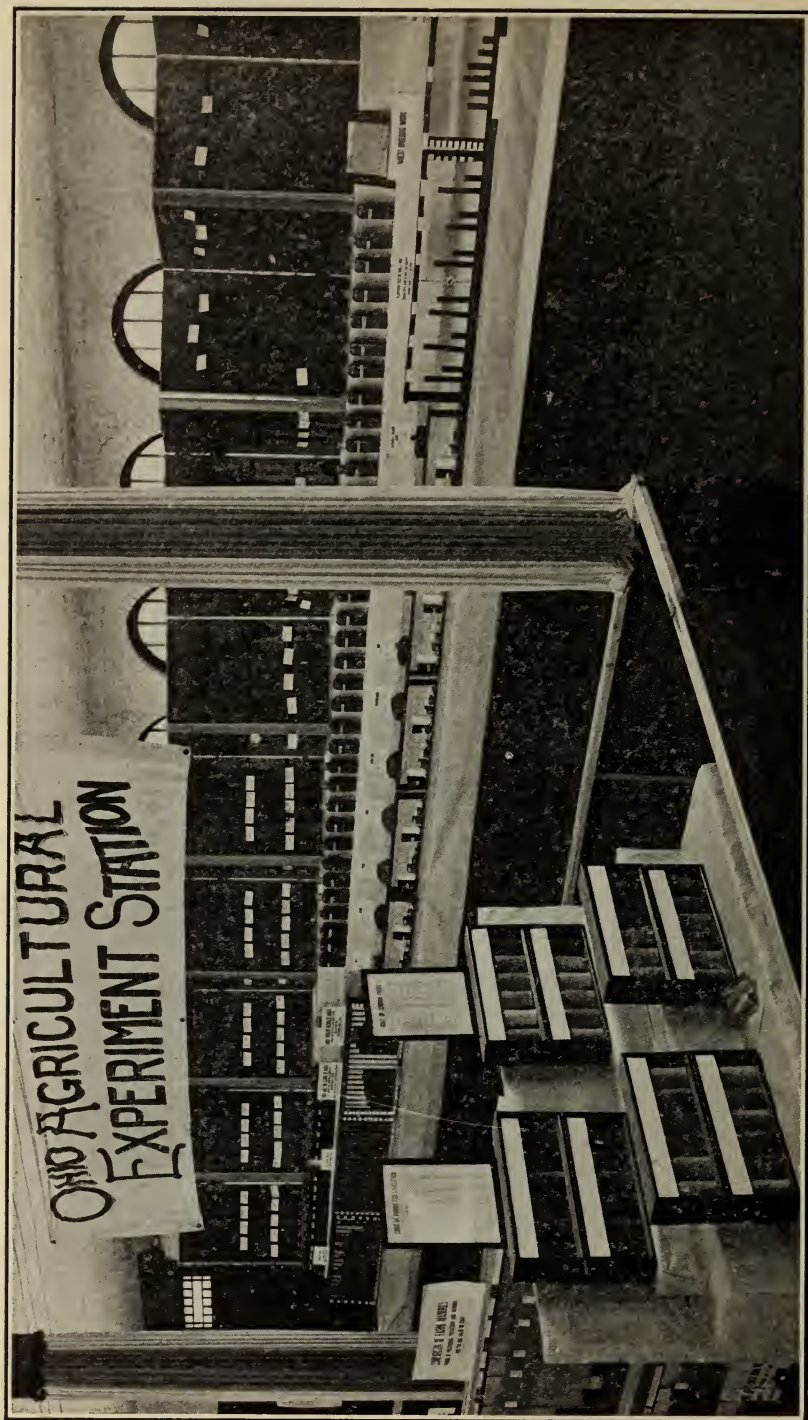


The variety display of apples.

The variety display of apples and potatoes varied somewhat at the different fairs. It excited much favorable comment and was frequently the means of identifying some specimen brought in by a grower. Much interest was also manifested in the exhibit showing the relative value of different fertilizers with potatoes; also in the plant breeding work showing the results obtained from using seed potatoes from high-yielding hills.



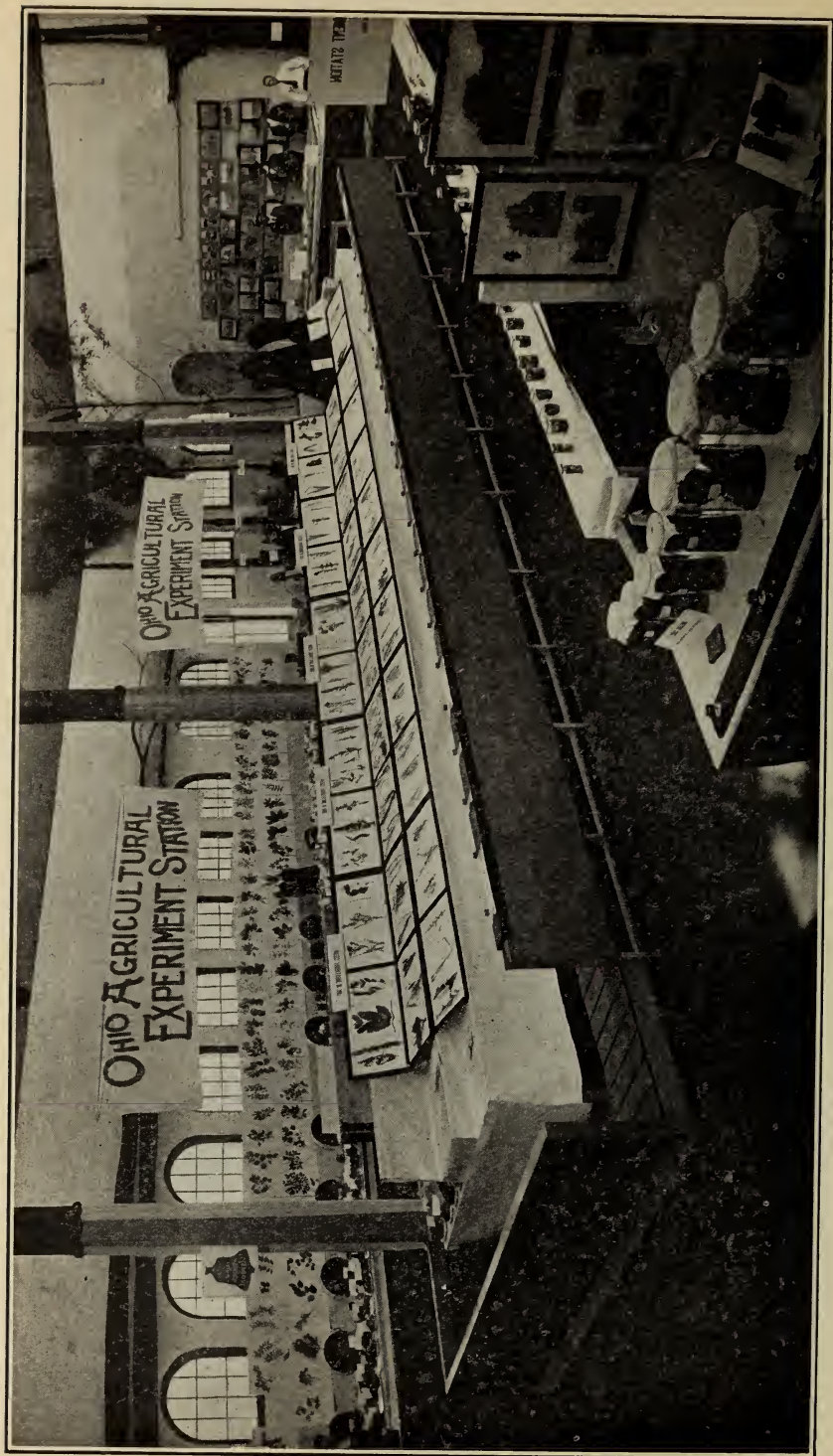
Exhibits of the Departments of Soils and Chemistry at the State Fair.



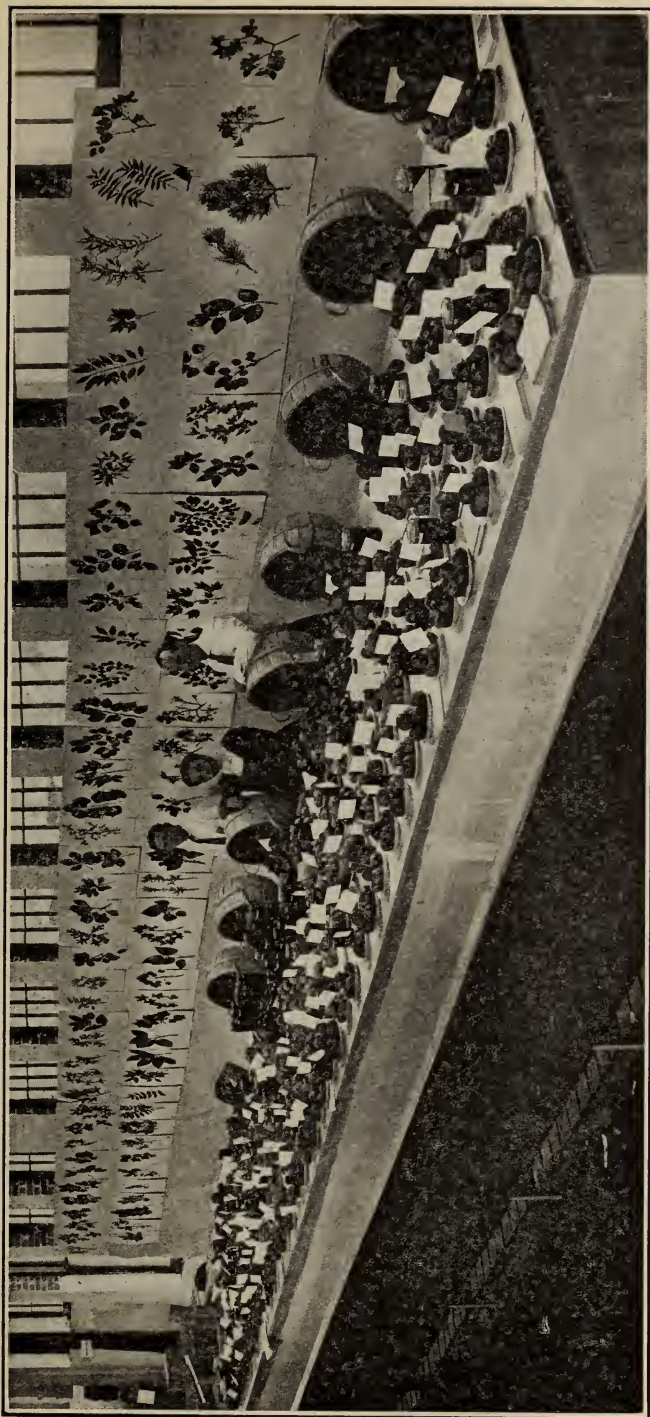
A part of the exhibits of the Departments of Agronomy and Nutrition at the State Fair.



Exhibit of the Department of Entomology at the State Fair.



The Department of Botany at the State Fair.



A part of the exhibits of the Departments of Horticulture and Forestry at the State Fair.

NUTRITIVE VALUE OF FOODS

The exhibit of the Department of Nutrition consisted of representative samples of some of the common foods for both human and animal consumption. The high cost and low nutritive value of some of the common breakfast foods as well as of a number of the commercial stock foods was very effectively shown.

THE STATE FAIR EXHIBIT

The exhibit at the State Fair was of the same general character as those at the county fairs. Some new features were added, though in the main they were amplifications of those made at the county fairs. In addition to the car containing Exhibit No. 2, which was sent to Columbus from the Fayette County Fair, another car was sent from the Station direct. In all there was used more than ten tons of exhibit material. This was installed in the west half of the East Central Building, the new quarters which had been assigned to the Experiment Station by the State Board of Agriculture—the area used for the exhibit measuring seventy by one hundred feet.

SPECIAL EXHIBITS

A few special features of the exhibit at the State Fair not heretofore described under county exhibits, were as follows:

By the Department of Forestry, an exhibition of fence posts made from the various kinds of timber commonly used for this purpose. The posts used in this display had seen actual service and the comparative durability was very effectively shown.

The Department of Chemistry made an exhibit showing the effect of lime on soil humus and formation of available nitrogen (nitrates) and the comparative effects on soil humus of equal amounts of lime (2000 lbs.) applied in the form of burned lime and limestone. The several amounts of humus were represented by jars containing organic matter, and the amounts of the nitrates by small tubes on the sides of the jars.

In another exhibit by this department there was shown the pounds of nitrogen, phosphoric acid, potash and lime in some Ohio soils, as peat soil, black clay loam, red clay loam, Miami clay loam and Miami silt loam. Samples of the soil were displayed in trays properly labeled. The amount and constituents of each soil were represented by different colored materials placed in tubes, using one for each sample of soil.

The Department of Agronomy showed the results of a number of tests with winter wheat, yields of best and poorest individuals, and later results from the best plants as tested in comparison with the original varieties upon tenth-acre plots. There were a number of photographs showing variation, manner of growth,

stiffness of straw, etc., in pure lines of wheat. The effect of thick and thin plantings of corn was shown by sample hills with four years' average yield. A special exhibit showing samples of flour, mill products and loaves of bread from ten varieties of winter wheat was particularly interesting and instructive. There were a number of photos showing varieties and strains of alfalfa descended from single plants, which showed variation as to hardness, proportion of leaves, manner of growth, etc., also of plants showing effect of inoculation.

The Department of Animal Husbandry made, as it did in 1908, an exhibit of live hogs illustrating a feeding experiment. Two of each of five lots of hogs were shown. The rations tested were as follows:

Lot 1. Cornmeal 1 part, skim milk, approximately 3 parts by weight, in dry lot.

Lot 2. Cornmeal 4 parts, soybean meal, 1 part by weight, in dry lot.

Lot 3. Cornmeal alone, in dry lot.

Lot 4. Cornmeal on mixed pasture (chiefly timothy and bluegrass).

Lot 5. Cornmeal on clover pasture.

Banners were displayed describing the exhibit and cards were distributed giving full details as to the results.

DAILY LECTURES

A lecture room equipped with rostrum and chairs had been provided by the State Board of Agriculture, and during the fair a number of lectures were given by members of the faculty of the College of Agriculture and of the staff of the Experiment Station. This is a feature which, with proper advertising and announcement on the grounds during the fair, is capable of much profitable development.

EXPLANATION OF THE EXHIBIT AT THE COUNTY FAIRS

The following gentlemen, members of the force of Farmers' Institute Speakers or prominent in agricultural work in the state, were secured by the Station to assist in the explanation of the exhibit: Mr. Cary W. Montgomery, of Newark, Mr. Horatio Markley, of Mt. Gilead, Mr. J. S. Brigham, of Bowling Green, Mr. Jno. T. Brown, of Mechanicsburg, Mr. C. R. Wagner, of Arlington and Mr. C. W. Waid, of New Carlisle. Several members of the scientific staff of the Station, including Director C. E. Thorne, were present for a short time at some of the fairs. No attempt was made by those accompanying the exhibit to give general advice concerning farm problems except so far as they were covered by results of actual ex-

periment work conducted at the Station. Many questions were referred direct to the heads of Departments for specific reply by letter. This has been found to be a good method of bringing the farmers into closer relation with the Station.

A member of the staff of the Experiment Station was in charge of the exhibits at each county fair, as follows:

Mr. G. T. Abbott—Greene, Clark, Hardin, Auglaize, Defiance and Brown.

Mr. M. O. Bugby—Erie, Sandusky and Wood.

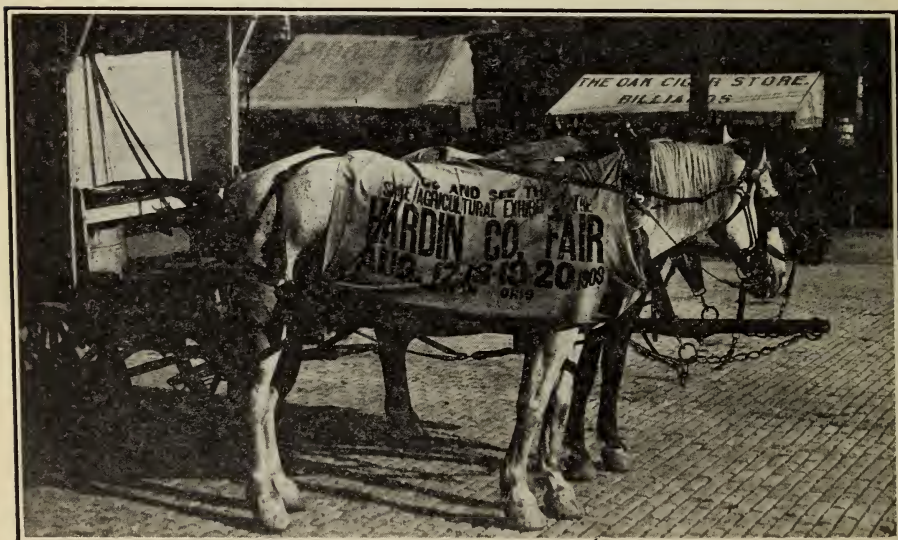
Mr. W. M. Cook—Montgomery and Logan.

Mr. W. A. Lloyd—Pike, Ross, Fayette, Van Wert, Knox, Warren Coshocton and Tuscarawas.

Exhibit No. 1 was accompanied throughout the season by Mr. H. C. Lewis, of Zanesville, as advance agent and Exhibit No. 2 by Mr. H. M. Dixon, of the Experiment Station, in the same capacity.

Almost uniform success attended the exhibits throughout the season. This success was largely attributable to the following causes:

1. The preparedness, uniform courtesy and readiness to assist, everywhere manifested by fair officials.
2. The splendid service given by railroads.
3. The excellent work done by the various gentlemen who assisted in the explanation of the exhibit.



Persistent Advertising helps much in making the exhibit a success.

4. The generous and friendly attitude of the rural press, which was manifest both previous to and during the progress of the fairs.

If any antagonism or carping criticism exists toward the Station it was not manifest at the fairs. The reception was everywhere cordial and the desire to cooperate abundantly manifest. Many farmers said the exhibit was all that brought them to the fair. Many who spent several hours in the exhibit one day would return the next with one or more neighbors who had come to the fair as a result of their enthusiasm. Every fair developed good missionaries who "went out" and "brought in" others and who did good work in explaining features of the exhibit which most appealed to them.

A REGISTER FOR THOSE DESIRING BULLETINS

A book with the invitation "If Interested in the Exhibit, Please Register," was kept at each of the fairs. The total registration at all the county fairs amounted to 5,115 and at the State Fair 2,640. Ninety-seven percent of those registering at the county fairs were adults seemingly thoroughly interested in the exhibit, while probably 30 percent of those registering at the State Fair were people who were in no way interested in the exhibit, simply registering as a matter of curiosity. Since the fairs, an opportunity to receive the bulletins and publications of the Station has been given to each of those registering. As a result of this work there have been added 950 new names to the list of those wishing bulletins and publications from the Station. The following table gives the attendance and the number registering at the different fairs.

CARDS AND BULLETINS

Cards describing the various experiments were placed conveniently accessible to all who wished them. A supply of many of the bulletins of the Station was carried with the exhibit and distributed to all who asked for them.

EXHIBIT OF THE COLLEGE OF AGRICULTURE, OHIO STATE UNIVERSITY

In connection with one of the exhibits, the Ohio College of Agriculture made a very attractive display of its work. This consisted quite largely of photographs of the University buildings, laboratories, apparatus, classrooms, students at work, etc. There were also large charts showing the course of study in the four-year, two-year and ten weeks courses in Agriculture and Domestic Science.

ATTENDANCE AND REGISTRATION AT FAIRS VISITED BY THE EXPERIMENT STATION FAIR EXHIBIT IN 1909

COUNTY	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		TOTALS	
	ATTEND- ANCE	REGIS- TRATION	ATTEND- ANCE	REGIS- TRATION	ATTEND- ANCE	REGIS- TRATION	ATTEND- ANCE	REGIS- TRATION	ATTEND- ANCE	REGIS- TRATION	ATTEND- ANCE	REGIS- TRATION
*Auglaize					10,000	169	20,000	110	8,500	9	30,000	288
Brown					1,500	51	9,000	132	1,208	102	19,000	285
Clark					4,148	71	5,832	100	7,813	19	20,690	193
Coshocton				3	1,300	86	16,624	322	3,985	99	25,737	507
Delfance					1,438	9	4,288	59	5,000	56	8,853	124
*Erie					8,000		12,000		2,488		25,000	297
Fayette					1,540	72	11,283	52	4,931	32	15,311	156
Greene					1,235	154	10,243	154	5,000	121	16,737	446
Hardin				17	5,000	65	15,000	161	3,290	76	27,000	329
Knox				27	137	15	3,240	162	7,000	17	6,667	194
Logan					4,000		10,000		10,000		21,000	162
Montgomery					5,000		13,000				46,000	193
*Pike	13,000				2,000	92	10,000	145			12,000	242
*Ross					6,000	25	10,000	67	5,000		21,000	92
Sandusky					2,320	38	7,248	161	9,373	53	18,940	232
*Tuscarawas					130	10	2,500	108	800	47	3,450	165
Van Wert					10,000	121	25,000	362	2,000	71	39,000	534
Warren					1,050		5,516	170	2,366	17	9,080	187
Wood					2,800		16,966		3,100		25,966	419
Total County Fairs												
Franklin (State Fair)	4 782		25,041		40,616		45 443		6 631		391,431	5,115
											122 513	2,640

* Attendance reported as estimated.

The Department of Agricultural Extension, which had charge of the exhibit, made a number of demonstrations with the Babcock tester; also simple experiments showing capillarity of soils, germination of seeds and many other helpful suggestions, showing the practicability of elementary instruction in agriculture in the rural schools. There was also available for examination quite a large number of books suitable for the introduction of this work into the schools and home. Particular effort was made to get in touch with the teachers of the state.

Prof. R. L. Shields was present at the fairs in Pike, Ross, Montgomery and Fayette counties and Prof. C. R. Titlow at those in Knox, Defiance, Warren and Brown counties.

WORK OF OTHER STATES

Twenty-six American Experiment Stations are using exhibits and demonstrations in connection with one or more fairs, and all report it a very effective means of bringing the work of the Station to the attention of those most in need of its aid. Minnesota reports very satisfactory results from the use of moving pictures, showing actual field work, and Maryland reports excellent results from the use of the phonograph, the cylinders used giving short talks from members of the Station staff.

HOW TO SECURE THE EXHIBIT

Persons desiring the exhibit to visit their county should get into communication with their County Agricultural Society, by which the application should be made to the Experiment Station. The application will be referred by the Station to a committee appointed by the Fair Managers' Association, which will select the fairs to which the exhibit is to be sent. Members of this committee for 1910, by which assignments have been made as given on page ii of this circular, are as follows:

Messrs. R. R. Grieve, Xenia
S. J. Vining, Celina
J. A. Knapp, Marion
A. E. Schaffer, Wapakoneta and
R. Y. White, Zanesville.

MEMORANDUM OF UNDERSTANDING

(To be used with Agricultural Societies)

Memorandum of Understanding by and between the Ohio Agricultural Experiment Station of Wooster, Ohio, and the.....County Agricultural Fair Association, duly entered in this the.....day of.....1910.

It is hereby mutually understood that, unless prevented by unavoidable transportation delays, the said Experiment Station will install one of its regular Illustrative Exhibits at the.....County Fair on Monday and Tuesday1910 and provide not less than three men to explain the various features of the exhibit on Wednesday and Thursday and until noon Friday of that week, without expense on the part of the said Fair Association, other than will be needed to comply with the following named conditions:

FIRST: To advertise thoroughly among the people of that section the coming of the said exhibit by means of notices in the premium list, reading notices in the various county papers, circular letters and otherwise.

SECOND: To provide an expert tent man with necessary help to put up the Experiment Station tent on Monday, to take it down at 1:30 p. m. Friday and to remain on the ground during the intervening time to rectify any storm damage.

THIRD: To pay to the Experiment Station \$20.00 for the use of its water proof tent.

FOURTH: To provide such lumber as may be needed to build tables, racks, etc., in connection with the exhibit.

FIFTH: To provide two draymen, each with a flat-topped wagon, who shall be ready to move said exhibit material from the car to the fair grounds upon one hour's notice and to remove same from the fair grounds to the car promptly at two p. m. on Friday.

SIXTH: To provide two men, one of whom shall be handy with carpenter tools, to help install, tear down and pack up the exhibit, these men to report upon request on Monday and promptly at twelve o'clock on Friday and to help on both occasions until dismissed by the Station's representative.

SEVENTH: To provide a responsible night watchman for the protection of the exhibit each night.

Signed:

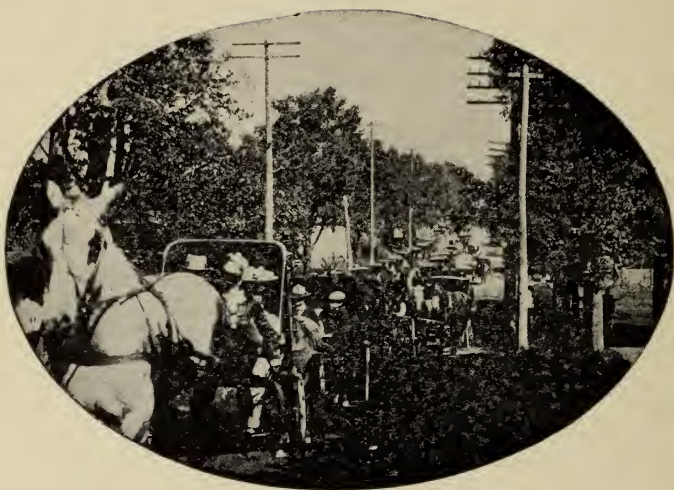
.....
President County Fair Board
.....
Secretary County Fair Board
.....
Representing Ohio Experiment Station

Approved:

.....
Chief of Cooperative Department
.....
Date

LIST OF COUNTIES VISITED BY THE STATION FAIR EXHIBIT

COUNTY	EARLY EXHIBITS	1905	1906	1907	1908	1909	REMARKS
Auglaize						*	
Brown					*	*	
Butler							
Clarke		*				*	
Clinton		*					
Cuyahoga						*	
Coshocton						*	
Defiance					*	*	
Darke						*	
Erie							
Fairfield			*				
Franklin (State Fair)	1885	*	*	*	*	*	Each year since 1885
Payette		*				*	
Fulton			*				
Geauga						*	
Greene						*	
Hardin			*	*			
Huron		*					
Hamilton						*	
Knox						*	
Logan				*	*	*	
Mercer						*	
Montgomery			*				
Meigs			*				
Preble	1904		*				
Putnam			*	*			
Pike						*	
Ross			*	*		*	
Richland							
Stark	1897-98				*	*	
Sandusky					*		
Shelby		*			*		
Summit			*	*	*		
Trumbull						*	
Tuscarawas						*	
Van Wert						*	
Warren						*	
Wayne	1891-1908						Small exhibit each year
Wood					*		
Wyandot							
40 Counties		6	9	7	8	20	In all 50 exhibits



Home from the Fair.

Ohio Agricultural Experiment Station

WOOSTER, OHIO, MAY 20, 1910

CIRCULAR No. 102

SPRAYING TO KILL WEEDS—SOME USEFUL METHODS

BY A. D. SELBY, BOTANIST

Wherever our ordinary culture methods fail us in the control of weeds, the matter of available spray solutions presents itself. This use of chemicals as sprays to destroy weeds has, heretofore, been better developed in the West, with its more limited labor supply and its restricted cropping systems. At present there seems to be little doubt that weed destroying sprays will find useful application in Ohio. Preliminary tests made last summer in cooperation with various farmers, and upon the Station farms, have given us preliminary information of considerable value.

The General Assembly has recently provided the funds for testing this matter under our Ohio conditions. This work is placed with the Department of Botany of the Ohio Experiment Station. It will be the endeavor to proceed with caution, and to cooperate with farmers, where possible, in various districts of the state which show conditions favorable to successful work.

WHAT WEED SPRAYS MUST ACCOMPLISH

What must be the line of operation or attack in the use of weed spraying chemicals? *These chemicals must destroy the weeds without injury to the crop grown.*

Most of our weeds are broad-leaved, or as we all know, plants with two seed-leaves. Our cereals and grasses are narrow-leaved plants which produce a single seed leaf. Upon the different reactions of these two classes of plants to the chemical sprays we must depend for our results—for injury to the weeds without harm to the crop. We find that *nearly all crops and weeds of the broad-leaved class of plants will be injured by these chemical sprays, and all weeds of the narrow-leaved class will escape injury by the sprays.* It follows

that crops of the clovers, alfalfa, soy beans, vetches and rape will be killed by such chemicals as destroy broad-leaved weeds, and that the sedges, quack-grass, crab-grass and wild onion or garlic will not be killed by spraying with such solutions as are not injurious to the grasses, cereal grains, etc. We may hope to destroy such weeds as mustards, dandelion, ox-eye daisy, white-top, thistles, carrot, parsnip, elders, poison ivy, ragweed, cockle-bur and horse-nettle, as well as practically all other broad-leaved weeds, by use of these sprays. At the same time, these sprays will leave blue-grass, timothy, red-top and other grasses, including the growing cereal grains, such as wheat, oats, rye, etc., without injury if properly adapted in strength and time of application.

Briefly summed up, *weed sprays, when properly adapted, should be available for the destruction of the larger portion of our pasture and grain field infesting weeds, when the methods are rightly and economically developed.* It would certainly be a travesty on our methods of culture to expect to substitute weed sprays for culture in the growing crop, such as in corn fields and the like.

WHAT SPRAYS TO USE

The most promising spray solutions tested are as follows:

Common salt solution, containing 3 pounds of salt to the gallon of water, applied at the rate of 50 to 75 gallons per acre sprayed.

Iron sulfate (copperas) solution, containing 1 3-4 to 2 pounds of iron sulfate to the gallon of water (100 pounds iron sulfate to 52 gallons of water). Use at the rate of 50 to 75 gallons per acre.

Calcium chlorid solution of same strength as salt and used at the same rate.

Sodium arsenite solution made from 1 1-2 pound sodium arsenite in 50 gallons.

Copper sulfate (blue vitriol) solution, containing 8 to 10 pounds of blue vitriol to 50 gallons of water; applied at the rate of 40 to 50 gallons per acre.

Salt has thus far proved the best spray tested in Ohio for Canada thistle, poison ivy, yarrow and horse nettle. In the Northwest sodium arsenite is given first rank. Salt is probably the most effective to destroy dandelion and some other weeds. Iron sulfate is very satisfactory to kill mustard weeds, ragweed, white-top, yarrow, and we believe a great many other broad-leaved weeds. Neither the salt nor the iron sulfate is regarded as offering any risk of application to pastures in which stock is running. Sodium arsenite is a very active poison and rather dangerous for that reason. Calcium chlorid has done very well where tested, but appears to be slightly inferior to salt. Copper sulfate solutions may be used in grain fields for mustards especially, but owing to the poisonous nature of the copper sulfate, it has a very narrow range of application.

THE COST OF SPRAY CHEMICALS

The spray chemicals mentioned are not expensive. The iron sulfate in sugar or granular form is a by-product in wire fence manufacture, and is offered at reasonable prices by the American Steel & Wire Co., of Chicago. In bags, this granular sulfate is quoted at less than 90 cents per 100 pounds, f.o.b. at principal Ohio points.

Common salt is a cheap chemical, being sold at about \$1.10 to \$1.25 per barrel of 280 to 300 pounds.

Calcium chlorid is obtainable at points in the Pomeroy salt district at a price of about \$9.00 per ton, less than car lots. It is packed in drums of 600 to 700 pounds each.

Copper sulfate is sold by almost all druggists, and costs from 5 to 6 cents per pound in barrels of 480 pounds each, or more at retail.

Sodium arsenite is rather an expensive chemical, upon which we have no quotations.

HOW TO APPLY WEED SPRAYS

The chemical solutions used as sprays to kill weeds should be applied, as all other sprays, by means of suitable spray nozzles which deposit the solution as a fine mist upon the surface of the leaves of the plant. One can use almost any good spray pump which will give good pressure, and direct the spray nozzles after the manner used in orchards and vineyards, or the traction potato sprayers can be so adjusted as to spray the whole area, instead of the row spaces only, thus applying the spray more satisfactorily.

More recently manufacturers have developed special forms of spray machinery in the West in which the force pump is run by traction, as in potato sprayers. A long rod or "boom" is attached to the rear of the sprayer, with nozzles at intervals of 8 to 12 inches; the outfit being thus driven over the grain field or pasture, secures the proper application of the spray. Certain of the western weed sprayer manufacturers have developed a "boom" with nozzles, which may be attached to any spray outfit. It is believed that these "booms," and some of the special sprayers, which, of course, are fitted with different sized tanks, will be found adapted to use in the Ohio tests. The following are some of the manufacturers of special weed spray outfits:

American Machinery Co., Minneapolis, Minn.

The Wallace Machinery Co., Champaign, Ill.

The Binks Spraying Machine Co., Fulton St., Chicago, Ill.

E. C. Brown & Co., Rochester, N. Y.

The Binks Spraying Machine Co., Fulton Street, Chicago, manufacture a special "boom" adapted to be connected with any sprayer.

WHEN TO APPLY WEED SPRAYS

In practice, the time of applying sprays needs to be adjusted to the condition of the growing crop, and the relative development of the weeds to be killed. It seems probable that very early spraying will be less effective than spraying after the weeds have developed a fair supply of leaves. The first spraying should be made not later than the beginning of bloom. Repeated applications need to be made as often as a new supply of leaves is developed, provided the condition of the host crop permits this. In grain fields, the best results will be obtained on practically all weeds, when only a single spraying is to be made, to apply the spray just as the crop is ready to occupy the land. With mustards, this will find some already in bloom. With ragweed, it is best to spray before the stems of the plants become hardened. With other weeds, of which these two are the type, as well as with these, it is often profitable to make an extra earlier spraying than that designated. For perennial sow thistle, wild lettuce and orange hawkweed, the spraying in grain fields should precede the blooming of the plants, and in cases of bad infestation with perennial sow thistle or the golden hawkweed, two sprayings should be made before the grain occupies the land. It is not clear just what can be done in the handling of bindweeds in grain fields, but similar principles will apply. For spraying in timothy or other grass meadows to kill white-top, yarrow, self-heal, ox-eye daisy and a number of meadow weeds, the principle is similar to that stated for grain fields, namely, to spray thoroughly just before the grass begins heading out. This will be during late May and early June for Ohio.

In spraying pastures to check weeds, the maximum returns will usually come from a beginning application in late June or early July before many weeds are coming bloom. After the initial application, the spraying should be repeated as often as there is development of new foliage to a marked degree.

In general, better results are obtained from applications made in cloudy weather, although any weather, except that followed by rain, is satisfactory.

SPRAYING FOR CERTAIN WEEDS

The spray applications need to be adapted, more or less, both as to kind and time of application, to the particular weeds present. This was shown in experiments to destroy poison-ivy on fences at Wooster. We had very little effect from spraying with iron sulfate, very good results from spraying with the common salt solution, and the results from calcium chlorid were slightly inferior to those from

common salt. Where the common salt was used, and two applications were made some three to five weeks apart, the poison-ivy vines were dead the following spring. Similar experiments were carried on at Carpenter, where we found that iron sulfate would have no effect upon the leaves of horse-nettle, while salt solutions were very satisfactory, destroying the crop of leaves, and forcing the plants to put out new leaves. Under these conditions we expect, by two or three successful sprayings, to kill a large share of the weeds in a single season—the more resistant plants being given a repetition of the treatment the next season.

In the case of mustard weeds, very good results have been obtained by the iron sulfate solution, and there is little difference in the results obtained upon timothy meadow weeds in general, such as white-top, yarrow, self-heal and several others, as between the applications of iron sulfate and those of common salt. On the other hand, Canada thistle is not destroyed satisfactorily by iron sulfate solution. It is killed down quite well by the common salt, and our western friends report even better results by the use of sodium arsenite.

Upon ox-eye daisy we need to have further tests, as well as upon a large number of different plants.

For dandelions the matter is an open question whether iron sulfate solution, or the common salt solution is the better for the purpose. We have made partial tests through two seasons at Wooster, and find that the first spraying should be made before any of the plants come into bloom, and that two or three later sprayings will probably be found profitable during the season.

WE HAVE YET TO LEARN ABOUT SPRAYS FOR SEVERAL WEEDS

As previously stated, in 1909 we learned what to use and how to spray, to keep down poison-ivy and horse-nettle, as well as white-top and yarrow. We have yet to learn the best way of handling ox-eye daisy, wild parsnip, iron-weed, osier willows, milkweed, velvet-leaf, bladder ketmia, bindweed and a large number of other common weeds.

The object of the work upon which we are now engaged is to determine just how to apply the sprays, and what sprays to use for the eradication of these weeds under our Ohio conditions. Of course, we realize that what has been done in other climates, upon the same weeds and plants, has more or less suggestion in it for Ohio. Nevertheless, our different climatic conditions may give very different results from those obtained in the Northwest,

IS WEED SPRAYING A PROFITABLE BUSINESS FOR OHIO?

As before intimated, it is yet to be proved whether weed spraying is a profitable business proposition under our Ohio conditions. We are entering upon this work in the spirit of inquiry. The small amount of work done in 1909 indicates some very desirable results within our reach with respect to freeing our Station farm and Test farms from such persistent growths as poison-ivy and horse-nettle. The Station hopes to investigate this matter of weed spraying in the spirit stated, and to be able to give, the results obtained, in the course of time, for the benefit of the public.

Whoever has no troublesome weeds will have no use for weed spraying. Whoever has troublesome weeds through slovenly methods of culture in cultivated crops, such as corn and potatoes, is not likely to be greatly assisted by weed spraying; but grass meadow lands, pastures, roadsides along our highways, along railroads and electric lines, and such grounds as parks and lawns, are open and offer a very wide field for determining the usefulness and profit of chemical sprays to destroy the weeds in them.

Ohio Agricultural Experiment Station.

CIRCULAR No. 103

Horticultural Series No. 3

WOOSTER, OHIO, JUNE 12, 1910

AUTUMN MEETING OF THE OHIO STATE HORTICULTURAL SOCIETY

LITTLE HOCKING, SEPTEMBER 17, 1909.

STATE FAIR MEETING, 1909

On account of the regular midseason meeting which was being advertised for September 17th, the State Fair Meeting was but an informal session, no program having been arranged. The members of the Executive Board were required to meet at this time, however, as the secretary's tenure of office had expired on the first day of August, 1909. The result of the Board Meeting was that F. H. Ballou was re-elected secretary for the ensuing year.

A standing committee was appointed, consisting of Messrs. W. J. Green and F. H. Ballou, for the purpose of endeavoring, if possible, to solve a number of problems relating to nomenclature of varieties of apples which have been causing confusion among exhibitors at the State Fair for a number of years.

AUTUMN MEETING AT LITTLE HOCKING, SEPTEMBER 17, 1909

This was one of the most excellent and successful midseason sessions in the history of the society. The meeting was held in conjunction with the Little Hocking Grange in the orchard of Mr. Chas. W. Oakes, three and one-half miles below Little Hocking, on the Ohio River. While this point was considered somewhat inaccessible because of its distance from the railroad station, and some doubt as to attendance seemed to exist, it proved that all uneasiness on this point had been quite unwarranted. The day chosen was perfect, and the boat which had been chartered at Parkersburg, W. Va., especially for the occasion, carried down the beautiful Ohio River, soon after sunrise, a generous company of enthusiastic, appreciative horticulturists who were out for what might be learned at the meeting.

Aside from the boat load of excursionists, the residents of southern and and western Washington County turned out in goodly number, many driving several miles to attend the meeting. A number of horticulturists from distant parts of the state was in attendance. It was estimated that there were present 500 persons—all interested in the wonderful results in fungus and insect control that had been wrought by the horticultural department of the Experiment Station in Mr. Oakes' orchard.

The large, 34 year old Rome Beauty apple trees of this orchard, where thorough spraying had been done, were heavily laden with large, smooth, sound, perfect apples while the unsprayed trees in the same orchard, and all orchards which had not been sprayed throughout the neighborhood and all that part of Ohio were producing only meagre crops of miserably small, scabby, wormy worthless fruit. It was a demonstration long to be remembered and one that will prove productive of a great awakening as to the possibilities of apple culture in south-eastern Ohio. The following papers were presented:

SPRAYING FOR THE FUNGOUS DISEASES OF THE APPLE AND OTHER CROPS

By A. D. SELBY, Ohio Experiment Station

"What is a fungus disease?" will be often asked in connection with such a title or with titles referring to diseases of plants caused by parasitic fungi. Around one's views or understanding, or, I might say, one's apprehension or grasp upon ideas of parasitism and the resultant effects of it upon the host crop or plants, we must group the opposed or opposing forces of our remedies, such as spraying, seed treatments, selection of resistant and relatively immune sorts and other possible agencies for the prevention or amelioration of crop losses through fungus diseases.

Should you ask me about my notion as to fungus diseases, I might reply that succinctly they are diseases produced in plants as a result of the attacks of parasitic fungi or bacteria. Further, these diseases are characterized by the way the parasite is propagated and scattered, which is usually through spores of microscopic size, and by any conveying agency, such as winds, movements of insects, animals or even of man. Further, that these diseases are not only favored or held back by reason of the special characters of the host plant, such as relative liability or immunity in being attacked, but also that other things being equal, these diseases are enormously swayed or controlled by the conditions existing, at any point, with respect to the moisture, especially that held as air humidity and by the temperature of the air which surrounds both the crop or host plant and the attacking parasitic form.

Our host plants, our crops have their optimum of moisture, temperature, etc. Their parasites have a very similar and often analogous and inter-related optimum of these very same conditions.

Viewing these processes of parasitic attack from the objective of their possible control, what is the basal principle, or what are the means to this end?

Inevitably there will be two viewpoints, viz.: 1. That of the plant or crop diseased, and 2. That of the parasitic fungus or bacterium. We are most concerned today with the side of checking the parasitic fungi which attack the apple, the potato and tomato and possibly the muskmelon. Upon the crop we must not inflict more injury than the parasite would have done. As to checking the parasite we must have a principle which is the basis for action. What is this principle? My friends, each of you formulate it in your own minds as I ask each one.

No simple formulation is without objections. I like this one: Disinfection of the crop. The principle of parasitic disease prevention through spraying rests upon the same basis as the treatment given to rooms in which patients have been ill from diphtheria, scarlet fever and smallpox. Both seek to kill, to destroy the spores or other propagating parts of the parasites—that is, to destroy the microbes, the conveying germs of the disease. I emphasize this matter of the

principle of disinfection by the use of fungus killing substances, called fungicides, because our mutual understanding of this matter rests upon the principle and the further fact that these spray or seed treatment substances will destroy the spores and other living parts of these fungi. It is not the moonshine, the weather or the presence of something away outside we are fighting. It is a number of actual living parasites which cause our losses. Although we may never forget that the moisture and temperature of weather conditions are of very great influence, these influence these diseases only as they favor the development of the parasite out of proportion to their influence on the host crop. When this happens the return from the host plants is disappointing to the grower.

THE USEFUL FUNGICIDAL SPRAYS

When we have infection through the spores or other parts of these parasites we are called upon to treat for the parasites. The disinfectants or sprays used on our crops are of different composition. For use on crops or trees in foliage the most used fungicides contain copper compounds as the active agent—Bordeaux Mixture, Bordeaux and Iron Sticker, Ammoniacal Copper Carbonate and Soda Bordeaux Mixture—all rely for their efficiency in killing fungi upon the copper compounds they contain in their final chemical forms.

In addition to the copper salts there are certain sulfids or soluble compounds of sulfur and some base, such as Potassium, Calcium (Lime), etc., among our fungicides. These appear to rely not on the base nor upon the sulfur but upon the particular combination produced in the making.

Potassium sulfid solution and more latterly self-boiled lime-sulfur mixture are examples of useful sulfid sprays. Self-boiled lime-sulfur mixture of the 10-10-50 formula may be used upon the foliage of the peach without leaf injury.

The following are the formulae of these sprays as published in the spray calendar, Bulletin 199, December, 1908.

No. 1 Bordeaux mixture.

Copper sulfate (blue vitriol)..... 4 lbs.
Quicklime (not air slaked).....4 lbs.
Water to make 50 gallons.

No. 3 Ammoniacal copper carbonate.

Copper carbonate.....6 ounces
Ammonia.....about 3 pints
Water, 50 gallons.

No. 7 Bordeaux mixture and iron sticker.

Copper sulfate (blue vitriol).....2 lbs.
Iron sulfate (copperas)4 lbs.
Quicklime.....6 lbs.
Water to make 50 gallons.

No. 10 Self-boiled lime-sulfur mixture. (As now recommended by the originator, W. W. Scott, U. S. D. A.)

Stoneline.....10 lbs.
Flowers of sulfur.....10 lbs.
Water to make 50 gallons.

The effective copper compounds of the Bordeaux mixture type have a philosophy that will bear repeating. You understand how vital to the health of the leaf of any fruit tree to the crop producing power of the tree and that remedies, if applied after the leaves are injured are too late to be of high usefulness. You

understand also that an apple after it has once been attacked by apple scab can scarcely be saved to the high class merchantable apples. The more useful sprays must be of such constitution and capable of such application that the spray is continuously present during the period of infection.

The continuous attacks of apple scab in the early season must be met by the continuous presence of an active fungicide. Were we to get all the growth of new shoots and foliage on the apple as promptly as upon some other fruits, the number of sprayings to be made would be modified. As it is in fact, the sprays require to be made to meet the conditions of new leaf cluster shoots as well as those of the blossom shoots upon the new growth of the season.

The effective copper compounds in the Bordeaux mixture are those copper salts precipitated in insoluble form by the addition of lime to the solution of copper sulfate. Formerly it was held that the compound thus precipitated is copper hydroxid. Now Prof. Pickering, of England, holds that various basic sulfates of copper are produced. In either case the compounds produced and applied to the trees are relatively insoluble when applied.

Once upon the trees these become soluble by the action of the carbon dioxide and the moisture in the air and are therefore present and immediately available when such are needed to check parasitic fungi.

With Bordeaux mixture and iron sticker the same conditions hold with the added sticker qualities believed to be present and to act in such a way as to make the action more prolonged and just as effective, or very nearly so.

Formaldehyde formulae for treating potato scab, oat smut, stinking smut of wheat, onion smut, etc., as well as a formula for corrosive sublimate applied for potato scab are published likewise in the Spray Calendar, Bulletin 199.

APPLE BLOOM AND APPLE SETTING IN 1909

Apple blossoms were much more numerous in 1909 than the present set of fruit would lead one to infer. In southern and central Ohio especially, the failure of the trees to set fruit or even to fecundate the blossoms was apparent quite early. Specimens were received from Gallia county quite soon after blossoming. These showed that only about 5 to 7 percent of the blossoms had formed fruits. A similar state of facts held in Jackson county, in Fairfield county, and doubtless in many other districts. In the first counties named, the orchards had not borne a crop in 1908 and the trees bloomed quite freely. The fruits were not there for the apple scab to take off if it were there to do so. But these trees and many others were too much pushed to get through last season's severe drought. It would seem that the stress from the drought resulted, with non-bearing trees, in reducing the food reserves so much that not enough vigor remained to insure fecundation of the blossoms formed despite conditions. On the other hand, bearing orchards of 1908 were often so much reduced in vigor by the drought that no blossoms or next to none were formed and no fruit was set.

I know that many persons who had a fair bloom on their trees last spring were much disappointed in the crop set by the trees. The explanation seems to lie in the exhausted tree reserves from drought of 1908. This again emphasizes the very important function served by the stored food reserves in the tissues of the fruit trees and should stimulate us to orchard methods which will insure the needed reserves even in stressful times.

SPRAY FOR APPLE FUNGI IN 1909

Plans were made for rather thorough spraying work on apples this season through the cooperation of the departments of Horticulture, Entomology and Botany. I shall speak only in relation to the Botanical side of the work so far as indications yield results now. The final results will be learned when the crops are gathered.

The weather was somewhat earlier and cooler during the apple blooming this season than in 1908, and the blossoms came earlier. However we had in most parts of the state an excess amount of showery, muggy weather before the trees were out of bloom. Indeed conditions for scab development were very favorable. The scab did not fail to get to work on the fruit where there was a chance and to attack foliage in all instances.

We planned in most spraying tests to compare Bordeaux mixture with Bordeaux mixture and Iron Sticker. At Carpenter, in addition, Self-Boiled Lime-Sulfur made a three-sided comparison.

Besides the scab the presence of an apple louse, *Aphis sorbi*, on many apple shoots complicated affairs. The secretions of these lice invited the sooty fungus and it made a very early appearance, showing about June 1 to 10 both before and after bloom.

Even the two spray treatments did not prevent all scab development upon the interior fruit clusters. However, the sprays usually saved enough fruits to tax the power of the trees to develop them on these interior clusters. Where these conditions of scabby fruit and sooty fungus were most noticeable at Chillicothe, the spraying just before the blossoms opened was rather imperfectly done and the proportion of scabby fruits was much larger than at other points where first spraying was done thoroughly. However, as the fruit crop was so disappointing in many orchards of Southern Ohio our observations were much more limited than had been planned.

In Northern Ohio, where weather conditions of last year as well as the present season have been more favorable in many ways, fine crops of apples have been saved at North Amherst and Erlin, Sandusky County and with very little scabby fruit. Detailed results are not yet available but the total outcome is satisfactory.

There is nothing to modify my judgement of one year ago, namely that spray applications of fungicides need to be made both just before the blossoms open and just after the bloom drops to insure successful results in scab prevention.

At Erlin, Sandusky County, Mr. Stokes has very fine results of scab free apples and has kept his crop this year on Winesap variety. He has used Bordeaux and Iron Sticker throughout the season, the Calendar formula 2-4-6-50 may have been partly used on early sprays but latterly and chiefly 2 lbs. copper sulfate, 2 lbs. iron sulfate and 4 lbs. lime were used. He had practically no spray injury.

The sooty fungus has apparently extended itself much less than was feared earlier. Have many of you observed recent development of a black sooty growth on the surface of the apples?

SPRAY INJURY IN 1909.

Spray injury upon apple foliage has been very severe on some orchards in southern Ohio this season and in northern Ohio there has been little or no complaint. The difference in injury may be explained in part by the differences as to rainfall and humidity in the two sections at critical periods. At Chillicothe

and Carpenter, we had abnormal leaf injury from the sprays which in the former case may have been due to abnormal soil conditions, since the orchard became in part defoliated in 1908. Another curious fact was the much larger interval than we usually expect to transpire between the spraying and the leaf yellowing and dropping. In these experiments we used the standard formulae of Bordeaux mixture, Bordeaux mixture and iron sticker, and the self-boiled lime-sulfur mixture.

At Chillicothe, on the same varieties, notably Mann and Grimes Golden, the leaf dropping was two and a half to three times as bad as on the trees sprayed with Bordeaux as it was on adjacent rows sprayed with Bordeaux and Iron. At Carpenter, we had self-boiled lime-sulfur as a further comparison. On the trees where lime sulfur was used, scab was not quite kept down and there was little leaf fall. Where Bordeaux and iron was used there was also light or moderate leaf fall, but on the trees treated with straight Bordeaux the trees were almost entirely defoliated.

I am impressed with the possibilities of the Bordeaux and iron mixture, using slightly reduced amounts of iron sulfate, say 2 to 3 pounds to 50 gallons as an apple spray in the future, but I can not in critical cases expect much less spray injury than from Calendar Bordeaux and iron formula since it is the copper compounds that seem to be responsible for the injury to foliage.

SPRAYING FOR TRUCK CROP DISEASES

Muskmelons—In the matter of muskmelon diseases we must remember that there are two distinct types of melon diseases which are liable to be called "blights". One of these types is a true leaf or foliage disease known as leaf blight and in some seasons is supplemented by the work of downy mildew. These leaf diseases are amenable to spraying. Perhaps even more conspicuous than these are the wilt diseases of muskmelons and cucumbers, which also attack watermelons. In the wilt disease the organism attacks usually at the root of the plant and causes sudden wilting; sometimes, however, through the action of biting or sucking insects, the organism is inoculated into a branch or into the vine some distance from the root. In this case the part beyond the affection dies after sudden wilting. We really have two distinct wilt diseases. One of these is due to a wilt infesting *fusarium* and the other is due to bacterium. Both of the organisms are more likely to be found in soil where melons or cucumbers were grown the year previous. Both of them are also liable to be spread by the attacks of biting or sucking insects, such as stink bugs, leaf beetles, etc. With the wilt disease you can only gather and burn the wilted plants in order to keep down the infection. There is no spraying remedy.

In spraying for a foliage disease, and especially for the leaf spot or leaf blight of muskmelon, one needs to get at the work, as in other spraying, before the damage is done. It seems wise to spray after the vines are one or two feet long, and to keep at it throughout the remainder of the season, seeing that the vines are covered with the spray. This should be accomplished by spraying at intervals of two to two and a half weeks. The best spray seems to be Bordeaux mixture, reducing the strength to three pounds. Muskmelons are very susceptible to Bordeaux injury, or spraying injury, in seasons like the present one, and this manifests itself by yellowing of the leaves in a narrow belt around the leaf border. Perhaps some of you can call to mind conditions of this kind in your sprayed crop of melons this year. You will doubtless recall a yellowing of

leaves in sprayed melon patches, but this affects segments of the leaves around the border rim. Because of the danger of spray injury it is best to keep the strength of bordeaux for muskmelons down to the 3-3-50 formula. The 4-4-50 formula may be used without risk on cucumbers, however.

Tomatoes—On tomatoes, seasons like the present soon bring out a great deal of leaf spot. This leaf spot is a true fungous disease, and the dropping of the leaves shortens the crop very seriously. This was true in my own garden at Wooster the present season, but since I was attending to other people's truck patches my own had to be neglected. In your district where the growth of early tomatoes and the use of the stake method of planting is practiced, you are liable to inroads of the leaf spot fungus. However, this leaf spot fungus will tend to hasten the ripening of the fruit, and increase the yield of them, at high prices. The bordeaux mixture is a very successful spray against the leaf spot, and could be applied from the time the plants are one to two feet high until the crop is made. However, the spraying and keeping down of the leaf trouble will delay the maturity of the crop, and while the crop will be greatly increased the actual profits may not be much greater from the sprayed tomatoes than from the unsprayed ones. This seemed to be the condition more especially a few years ago when I was conducting some experiments in tomato spraying in cooperation with Mr. Chas. F. Dyer of Marietta. Possibly other conditions may have come in and I invite your impression about them.

Tomatoes are also attacked by wilt diseases of two kinds; one due to a fungous *fusarium*, and the other due to bacterium; but in both these wilts the only thing is to remove and burn the diseased plants, as with muskmelons. In the case of fruit spots, to which you are not very subject in this region, so far as I know, the bordeaux spraying will yield fine results in keeping down the decays of the ripe fruits, or of the fruits from near the time of ripening. The spraying on the other hand will not be effective in keeping down the point rot of green tomatoes, which is very liable to occur in dry seasons like last year, or if the spray will prove to be ultimately successful as yet it is only partially so. We seem to have in dry seasons a bacterial infection of the blossom end, and as yet our spraying methods have not been adapted to prevent this serious infection. At this time we can only express the need of more knowledge.

Potatoes—In spraying potatoes in this part of Ohio we may leave out of ordinary consideration the prevention of late blight. It is true that occasionally on wet, cold seasons, and with very late planted potatoes, we may have some late blight this far south, but this will probably not happen oftener than once in 10 or 15 years. With the early blight, on the other hand, and the predisposition in southern Ohio to periods of early summer and midsummer drought, we are very liable to have serious outbreak. Whenever these early summer conditions result in abundance of leaf sucking and leaf puncturing insects, especially flea beetles, we may count on diseases following rapidly in the wake of the insect injuries. With normal seasons, the results of potato spraying are to be expected to show a small profit value, not a large one. In abnormal seasons like 1908 thorough spraying of a crop in this region should yield a good profitable balance. You will understand the spraying is made to keep down the infections from the early blight fungus, and to prevent the collapse of the leaves in the manner described as tip burn. From the results of the last two seasons the bordeaux mixture 4-4-50 formula, and bordeaux and iron sticker of about 2-3-5-50 formula, may be safely recommended for potato spraying.

Recently in northern Ohio, starting at the Experiment Station, we have had a serious development of the potato dry rot, *Fusarium oxysporium*. Not only did this fungus kill out a small area of plants entirely in potato plots, but it is now believed to be the cause of premature dying of the larger part of the potato plots. The infection from this fungus may come either through the soil or through seed. I believe that in the present case it may have come, partly at least, through the seed, and we are just now endeavoring to make a careful field study of the trouble. The indications are that locally it is often confined to fields on particular farms throughout the northern Ohio potato region that have this premature dying of the potato tops, even where thoroughly sprayed. This will be explained by the seed infection and would not prove that spraying is without value. We wish to learn the actual state of affairs before offering much more than caution in the choice of seed at this time.

Q. We have a moderate crop of Ben Davis, with a little scab; a few Rome Beauty; the Grimes Golden are quite perfect, and no scab; they are quite free from fungus diseases. Now do they need spraying or not?"

A. "Ben Davis, Gano and Baldwin will come nearer producing a perfect crop without spraying than any others. Rome Beauty, White Pippin and Winesap are the other extreme. We did not prevent all of the apple scab by spraying in Chillicothe. I think that probably there is a different rate of development of the scab in the Grimes. I do not think that you can grow Grimes ordinarily without spraying."

Q. "How about spray injury?"

A. "Leaf injury is the more vital. Spray injury this year was a little strangely marked. Spray injury developed this year where no spraying was done. We had previously thought that it was caused exclusively by spraying, but it came to a certain extent this year where no spraying was done. There was a rusting on unsprayed trees. The injury from spraying is much less than from the apple scab. The injury from spraying might place the apples in second class, but many people say that they still sell as first-class apples."

Q. "Have you sprayed peach trees successfully?"

A. "Yes."

Q. "How much spray do you put on?"

A. "There are two features in peach spraying. All Chinese types like Elberta and Boyer are very liable to leaf curl. Spray before the blossoms open with lime-sulphur or Bordeaux mixture, for the leaf curl on the Elberta. With the Salway, Late Ware, Morris' White, and Heath Cling, spray the foliage with Bordeaux mixture, two or two and a half pounds to five, as eight pounds will

injure the foliage too much. Self-boiled Lime-Sulphur is successful as it will not injure the foliage. Use a 10-10-50 formula. This will not injure the foliage of peach trees and will give fine results. Make two or three applications."

Q. "How about summer spraying for apples?"

A. "You can prevent apple scab by using Lime-Sulfur in the summer time. This was found out in New York. Bordeaux mixture is much worse than Lime-Sulfur. If we can be as successful as the New York people were this year with Lime-Sulfur it is well worth trying. Bordeaux mixture is being used in some parts of the country with success. However, some people say it cannot be done."

Q. "Can you spray plums?"

A. "You can spray plums of the European varieties with standard Bordeaux mixture. If you spray the Japanese and American varieties at all use self-boiled Lime-Sulfur."

After dinner Mr. Selby showed apples from Carpenter. Those which had not been sprayed had much sooty fungus and scab. Those sprayed with Bordeaux mixture had a little spray injury, and there is danger of injuring next years crop through loss of foliage this year. He also showed apples sprayed with Bordeaux and Iron Sulfate, which were in excellent shape, and free from blemish. Those sprayed with Lime-Sulfur had a little scab and sooty fungus.

SPRAYING FOR INSECT FOES OF THE ORCHARDIST

By H. A. GOSSARD, Ohio Experiment Station

Ladies and Gentlemen:—The orchard in which we are assembled represents a part of a general orchard plan entered into by the departments of horticulture, botany and entomology of the Experiment Station for the purpose of demonstrating that Ohio can grow apples in competition with any other parts of the United States. More or less experimental work in orchard spraying has been done by the Experiment Station throughout the period of its history, but one of the notable experiments in spraying was conducted by the Department of Entomology in the orchard of the Messrs. Schmitkons of Lorain in 1907. This orchard comprises about 25 acres of trees, something like 20 feet tall, with an equal spread of limbs. The principal varieties represented in the orchard are Baldwin and Ben Davis, but 25 or 30 different varieties are grown. During the season of 1907 the gross return for the crop was somewhere in the neighborhood of \$4500 while the cost of treatment was less than \$200. The spraying was done with a gasoline power sprayer having a 250 gallon tank and a tower built over the trucks so that one of the operators standing on the tower would have his feet elevated 5 or 6 feet above the ground and with a bamboo pole 10 feet long was enabled to reach into the tops of these trees very conveniently. At the end of the rods were used some goose-neck crooks made by bending gas pipe at

an angle of 15 to 20 degrees. Most of the spraying companies now make these crooks, or at least angled nozzles. However, they can be made by the local blacksmith from 3 or 4 inches of gas pipe threaded at each end; one end to screw into the end of the extension rod and the other to fit into the nozzle. When the rod is extended at something of an angle, the additional angle given by the crook throws the spray downward and into the cups of the bloom. When apples first bloom the flower end is turned skyward and the apple remains in this position for about ten days or two weeks after the petals fall. Since about 90 percent of all the codling worms enter the apples through the calyx cup it is very essential that a goodly amount of poison be driven into the flower ends of the apples so as to destroy the worms when they take their first meal. It is also desirable that considerable power be employed to drive this spray to the desired location. From 100 to 150 pounds pressure is advisable, but good results can be obtained with lower pressure provided the operator is persistent enough to remain at the same tree until it is fully covered. Upon all these trees we used from 10 to 15 gallons of spray for the first spraying after bloom. The greater part of the orchard was sprayed with Bordeaux mixture in combination with arsenate of lead. The first spraying had 4 pounds of copper sulfate, 6 pounds of lime and 3 pounds of arsenate of lead. For the second spraying about two weeks after bloom the copper sulfate was reduced to two pounds and a considerable part of the orchard was not sprayed in this second treatment. A third spraying with arsenate of lead alone, using three pounds to 50 gallons of water, was given in the latter part of July to some of the plots. There was considerable injury from Bordeaux burning both on fruit and foliage. However, the apples ripened up quite satisfactorily through the russeted skins, and the fruit was first class at harvest time though, of course, it would not go as fancy fruit. However, there was no difficulty in disposing of it at \$3.50 per barrel, and a great many barrels were disposed of locally at \$1.50 per barrel. During 1908 we transferred our operations to an orchard of about 14 acres located a few miles from Fremont in Sandusky county. This orchard is the property of Mr. J. A. Stokes and the trees in one of the 4 acre blocks were about 22 years old, in another 4 acre block about 20 years old and in another from 12 to 15 years old. There were two acres of very old trees—40 to 50 years. We likewise used a power sprayer here. Owing to the great size of the trees we were not able to reach the tops of them so satisfactorily as in the Schmitkons' orchard. However, by putting on a brass extension of three or four feet to the end of the 10 foot pole, we succeeded in covering the tops of most of the trees. We used weaker mixtures in this orchard than the preceding year, the principal formula being 2 pounds of copper sulfate, 3 pounds of lime, and 3 pounds of arsenate of lead to each 50 gallons of spray. On some of the plots arsenate of lead alone was used at the bloom, and then a fungicidal application was given 10 days or 2 weeks later. The fungicides used for this purpose were Bordeaux mixture, self-boiled lime-sulfur made with cold water, and commercial lime-sulfur. The fungicidal applications were a little too late, we think, to give best results and some scab developed on all the trees that were left until the second spraying for the application of fungicide. Very little scab developed upon the Ben Davis and Baldwin trees that were treated with Bordeaux immediately after bloom, but was quite conspicuous upon the Winesaps and a few other varieties especially susceptible to scab.

The orchard had been sprayed very thoroughly with lime-sulfur wash just as the buds were swelling and this doubtless contributed very much to hold the scab in check. There was practically no burning of fruit in this orchard, but

the weather was almost ideal for spraying at the time the application was made. From this 14 acres of orchard the gross receipts for the crop of 1908 was \$7,400. A single acre of Ben Davis trees yielded about \$1,408 gross, or more than \$1,000 net. The trees for this acre were not selected in any way, but every tree in the block was counted whether it had on it few apples or many. During the present season the Department of Entomology has had a number of different orchards located in different quarters of the state, under treatment. One of them is the Schmitkons' orchard, already mentioned; another is the Stokes' orchard, which gave a heavy crop in 1908; another is located at Mantua in Portage county; one is in Gallia county; another in Jackson county: then we are using the Station orchard at Wooster; also a small family orchard of three or four acres near Wooster. The orchard at Mantua has been defoliated by canker worms a number of seasons, and we therefore anticipate a light crop upon it this year, but see no reason why it should not give a good return next season. The orchards in Gallia and Jackson counties suffered so severely from drouth last year that they did not have sufficient vitality to hold their crops this year, though they bloomed heavily. We are confident that they will produce a good crop next season unless frosts or something of that character intervene. It is our desire to carry on experiments in all these orchards through a period of years so that we may strike an average and know what we can reasonably expect from Ohio orchards.

The greatest consideration in spraying apples is to be sure that enough liquid is applied. Do not be afraid of wasting a little spray. It is not wasted, even if it does run off on the ground. The old idea of employing a mist spray and ceasing the application before dripping begins, is not so successful as a heavy application. I believe there is less burning of foliage when the trees are sprayed until they drip, because in that case the leaves are bathed with the spray, all of the spores of disease are thus destroyed, and instead of the drops collecting on the bottom sides of the leaves, remaining there and burning the edge of the leaf, they roll onto the ground, leaving a comparatively small amount of spray adhering to the lower edge of the leaf. I prefer making the spray very weak and using an abundance of it. Trees such as you see around you, will need from 10 to 15 gallons of spray, depending upon their size, for the first spraying after bloom. If this spraying is thoroughly made the crop for the year is practically insured whether or not any additional applications are given, though it is advisable in many cases to give a second and oftentimes a midsummer application. If growing fancy apples, it may be necessary to spray even oftener, but good salable apples, free from worms, can be obtained in the manner I have described. For southern Ohio and for varieties of apples that are particularly susceptible to scab, I presume it is the part of wisdom to spray with Bordeaux mixture after the leaves appear and before the trees are in bloom. If a very thorough spraying is done with lime-sulfur just when the buds are opening I am inclined to believe that some varieties in the great majority of seasons will need no spraying with Bordeaux until after the bloom falls.

Regarding the question of pumps, orchards of six acres and upward should have a power sprayer of some description. Personally, I prefer a gasoline engine as a source of power, but traction sprayers and compressed air sprayers are adapted to certain uses and of course deserve consideration. For orchards of 4 to 6 acres, powerful hand pumps or power hand pumps, capable of maintaining a pressure of 80 to 100 pounds without overworking the man at the pump

handle, are desirable. For smaller orchards barrel pumps are used, but where there are only from one to a half dozen trees, bucket pumps may be used, though they are somewhat inconvenient for such use.

It will cost from 25 to 50 cents per season to spray one tree of the average size shown in this orchard. Such trees ought to give from 8 to 15 bushels of apples each, and since they produce very little if unsprayed, it is readily seen that the profit from spraying each tree will range from 5 to 12 dollars if apples bring in the neighborhood of one dollar per bushel. Since our population has increased so much in late years, while the orchard area all over the country has decreased owing to the ravages of the San Jose scale etc., it will pay every owner of apple trees, whether he has one tree or many acres of orchard, to take good care of them. In fact, there is no part of the farm that will pay a higher dividend on care and attention than the apple orchard.

Q. "Do you use arsenate of lead with Bordeaux mixture?"

A. "Yes. We use it with Bordeaux mixture. It is all right."

Q. "Why does Mr. Gossard prefer arsenate of lead, at 10 cents per pound, instead of Paris green, at 30 cents per pound?"

A. "Arsenate of lead kills more worms than Paris green, and sticks on the trees much longer. The extra cost of arsenate of lead is much more than paid for by the larger crop."

Q. "How much spray mixture do you apply at a spraying?"

A. "Ten or twelve gallons at an application after blooming."

Q. "But will it not run off the leaves? I only use about three or four gallons. Is more necessary?"

A. "It will drip, but let it keep on dripping. My observations lead me to believe that when only enough spray is put on to stick that it sticks on the leaves in drops and is likely to burn holes in the leaves. When it runs off the leaves are freer of fungus and there is less liability of leaf injury."

Q. "What is the cost of spraying trees the size of these (30 years old), three times each?"

A. "I think that it costs about 40 cents or 50 cents per tree for a season's spraying. Possibly a little more."

Q. "What is the trouble when peach trees live one or two years and then die? What is the matter?"

A. "It might be borers, but I could not say without seeing the trees. It might be yellows or some other cause."

Q. "How do you get rid of the borers?"

A. "The borers are caused by a moth that lays its eggs in the bark of the tree near the base of the trunk. If you have only a few trees dig out the worms with a knife and kill them. It may help to spray with Lime-Sulfur. Bank the trees to a height of eighteen inches with earth and leave it until the first of October and then

remove it and give the trees a chance to harden up before winter. This will make the moths go higher up on the trunk to deposit the eggs. By running a wire into the holes where the borers are you will likely kill some of them."

Q. "What do you do for bitter rot?"

A. "That belongs to Mr. Selby."

Professor Selby: The bitter rot spray has to be applied after the other applications. If you are treating for the bitter rot follow up the spraying for the codling moth, rot and scab with two or three applications of ammoniacal copper carbonate as described in the spray calendar. This will not injure the salability of the fruit, as Bordeaux mixture will. Mr. Cox says that Bordeaux mixture will not injure the salability of the fruit, but our conditions are farther north than Mr. Cox's.

Q. It has been difficult for me to save my Smith Cider for the past three years. We had the brown rot, which comes in as ripening time approaches. It is light brown to black in color; what is the remedy?

A. There are two rots, the brown and the bitter rot. They have very much the same appearance, being small, circular depressions, but the brown rot is a lighter color than the bitter rot. The bitter rot is usually a very dark color, nearly black, while the brown rot is a comparatively light brown. If you taste an apple that has an advanced stage of the bitter rot, you get a decided bitter taste. If you taste an apple with the brown rot the bitter taste is not noticeable. The treatment is given fully in the spray calendar, bulletin 199, of the Experiment Station.

Q. Has the Station tried a preparation called "Scalecide"?

A. Yes. We have used it. It is a good remedy for the San Jose scale.

Q. Can you use it in the fall?

A. It may be. It is used in the fall pretty generally over the United States without any bad results. I think it is all right.

Q. What can you do for pear blight?

A. There is no satisfactory remedy for pear blight. Perhaps Mr. Selby can tell us more about it.

Mr. Selby: I do not think that any man can grow certain varieties. I do not think that any living man can succeed with Flemish Beauty or the Bartlett in this region. Most people in this region can succeed with the Summer Sugar Pear or the Seckel, which seem almost immune from blight. Least, probably the Keiffer. Next and in the same class will come the Duchess, Sheldon and possibly the Anjou.

The blight is produced by a bacteria which lives over on the blighted wood. At the time when the pears bloom this bacteria secretes a substance from the spores. The bees visit this secretion, and then go to the blossoms, and the fungus develops in the nectar and pollen of the blossom.

Use Lime-Sulfur spray and cover the trunk of the tree. There is no specific remedy for pear blight. Cut off the blighted wood and burn it. It may be cut off now, but be sure and do it again before the trees bloom in April.

Q. Can grape rot be controlled?

A. We have handled all of the commercial varieties and grown them successfully. The treatment is all boiled down in the spray calendar, and the results are all shown in the bulletin of the Station "Spraying For Grape Rot". Get to all the new clusters before the blossoms open; otherwise the black rot fungus will get ahead of you; then spray after the blossoms fall.

With regard to the Norton Seedling will say that as it is a special case it requires special investigation to solve it.

Q. Why is it that some varieties do much better on the side of a building than they do on a trellis?

A. The explanation probably lies in the fact that when they are on a building there is less opportunity for moisture to collect on the clusters of grapes, thus affording less opportunity for the fungus to work on them.

APPLE GROWING IN SOUTHERN OHIO

By U. T. COX, Proctorville

At the New York State Fair I saw results of spraying with the lime-sulfur solution, a commercial brand, for apple scab and there was no russetting of the fruit at all and where sprayed with the Bordeaux it was very rusty and some of it deformed. It seemed to be a better spray than Bordeaux as they used it, giving as good results in preventing scab with no injurious effects. They added arsenate of lead for the codling moth with good results, notwithstanding Mr. Gossard saying it will not do. As he has strongly urged thorough work in spraying I want to emphasize the fact and add that if three men are to run a hand spraying outfit I advise putting two of them on the pump handle and one to hold the nozzle. Two men can give good pressure and one can not, and under high pressure the liquid will be discharged as fast from one nozzle as from two with ordinary pressure and it will spread better and do much more effective work than with low pressure. A power sprayer is the only thing for effective spraying if one has enough orchard to justify such an outfit. It does not require a very large orchard for one machine to pay for itself either. In the west they have an outfit for every 10, 15 or 20 acres of bearing orchard and I would suggest getting a good outfit if one had five acres of good apples, or less if the right man has it and the right kind of fruit.

If we go into a community where there are plenty of orchards that are well taken care of they have plenty of buyers for the fruit and as competition is the life of trade the fruit brings better prices; and as fruit from any certain locality where it is well grown and packed, and graded honestly, brings better prices in the markets, the buyers want such for the trade and they can sell it to better advantage than that from unknown parties, or from localities not known as apple sections. I understand Mr. Oakes has sold his crop at \$3.50 per barrel and if there were plenty more orchards around here that had been well sprayed and had good fruit he would likely have sold them for \$4.00 per barrel. As he has only just begun spraying and demonstrated that apples can be grown here successfully, even when he did not do a thorough job as we can see by the looks of the tops of the trees where the spray did not reach and the foliage is not the best, and some of the fruit scabby where they get the best fruit from unsprayed trees, so we may conclude that with better appliances and better work they can grow apples here that will compare favorably with those grown in the far west if we give the trees the attention they do out there. I feel certain that if this orchard had been sprayed another time late in the season, the last of July or first of August, for the late brood of the codling moth and leaf troubles that the fruit and foliage would be found sticking better.

On the hills generally we must do something with the orchards besides cultivating, and the sod mulch seems to be the best plan; it works well even in the bottoms, but then one must mulch instead of mowing the grass and taking it off as hay. One can cultivate if he wishes on land that will permit it, but I am in favor of mulching if properly done to conserve moisture and make fertility available.

Q. How far apart do you plant Rome Beauties?

A. Thirty to thirty-five feet on soil like this. (First bottom, Ohio river.) In the hills plant them twenty-five to thirty feet apart. Plant the rows around with the curvature of the hill, so that you can drive around the rows. Do not plant the rows up and down the hills. Plant the trees a little closer together in the rows than the distance between the rows. Say have the trees twenty-five feet apart in the rows and the rows thirty feet apart. If possible set the trees out in grass, as I think this will give the best results. I would recommend setting trees twenty-five by thirty instead of fifty or sixty by thirty. Set the trees fairly close on the hill land, as it will protect the soil and keep more moisture in the ground than if the trees were planted farther apart.

Q. Would not the evaporation from the trees be greater than the evaporation from the ground if the trees were planted farther apart?

A. It might be. That is a matter that must be found out by experimenting; but I would recommend planting the trees closer together.

Q. What would you do with trees where possibly one third of the branches are dead?

A. Trim up the trees, and try to get water-sprouts to fill up the vacant spaces.

Q. Do you cut the limbs off close to the trunk or leave a stub?

A. Cut the limbs close to the trunk is my advice. Some people say to leave a stub, but I would cut close to the trunk and then paint the wound.

Q. Do you spray for the foliage, and what do you use?

A. I do spray for the foliage. I think it makes the leaves stay on the trees longer, which causes the apples to stick on the trees longer, ripen up better and color up better. I spray from the middle to the last of July and use diluted Bordeaux mixture. About two to three pounds of blue vitrol to four or five pounds of lime, and a little arsenate of lead to the fifty gallons of water.

Q. Will it do to prune trees at any time in the year?

A. I prefer to do my pruning in the spring. When you cut the limbs off in the fall they check and crack badly if not painted. Pruning a tree in Summer when it is growing too fast may bring it into bearing earlier. I like to see the limbs down close to the ground. They may just as well be down to within a few feet of the ground, and bearing apples, as to have a vacant space there.

Q. Can you keep sheep in the orchard?

A. Keep the sheep out. If you want an orchard get rid of the sheep.

Q. How can you get rid of the rabbits in the orchard?

A. I keep the weeds and grass down in my orchard and am not troubled much with them. If I was I would kill them, or if I could not kill them myself I would hire someone to kill them for me. You can kill them, trap them, or place wire screens around the trees for protection.

Q. What are some good apples?

A. Grimes Golden and Jonathan for earlier varieties, and Rome Beauty and Rawles Janet for winter apples.

Q. How about the Ensee apple?

A. It has a fine quality, good size. The young trees bear when five or six years old. I believe that it is worthy of a trial. See that it is tested before you go into a new variety or you will get bit ninety-nine times out of one hundred.

Q. How about the winter Banana?

A. A fairly good apple. I would not advise anyone to put out an orchard of it. Do not go farther before experimenting with it.

Q. What of Stayman Winesap?

A. I do not know what it will do.

Q. What do you think of the Delicious?

A. Tastes real well. There are better for this region. Some in the Ohio valley are doing well. It is a fall apple here.

Q. What of the Hubbardston?

A. Too far south for it, I think. I do not think I would plant an orchard of it at present until I knew more about it. Too much of a fall apple.

Q. In spraying, some people use a pole with the fluid going through the pole. Others use a pole with the hose fastened to it. Which is best? It makes me tired to hold up a pole, with the hose fastened to it, for a day at a time.

A. By all means get a bamboo pole lined with brass or even aluminum, though that costs more, I believe. It is much lighter.

Chairman Waid said he thought they ought to hear from Mr. Ballou, who had charge of the spraying work in the orchard they had been inspecting.

Mr. Ballou said that the orchard had been sprayed to some extent before Mr. Oakes had told him that he sprayed quite differently from the way it was sprayed this year. In fact, he had sprayed very indifferently in comparison with the way it was sprayed this year.

Q. How much spray did you use to a tree, and what was the cost?

A. It ran from seven to eight gallons to a tree at each spraying. The cost of spraying the trees was from 25 cents to 30 cents per tree for three applications each. About 10 cents per tree for each spraying. This is for the material alone. The labor would be extra.

Q. Why are some of the apples here dropping so much?

A. Some of the apples were not sprayed. The apples in our sprayed plot have been dropping very little.

Chairman Waid then called upon Mr. Oakes, the owner of the orchard, for a few remarks.

Mr. Oakes stated that he had been fully converted to the spraying business. Last year he went through the orchard and found one little, knotty apple. He intended to grub out the entire orchard as soon as he could find a market for the timber. Last spring Mr. Ballou came around and asked him what seemed to be the trouble with the orchard. He told him that he thought it was the cold weather in the spring, which prevented the apples getting enough sap to develop. Mr. Ballou said he thought he could help things, a little; and, Mr. Oakes said, "you can look around and see the results. I am sorry now that Mr. Ballou did not get after me with a little hickory oil and make me get up into the trees and spray all of them

thoroughly. This orchard is past what I used to believe to be the age limit of a Rome Beauty orchard—thirty years. I now think that I can make it last as long as I live.”

Q. What will you do with your orchard now?

A. I propose to go through the orchard, thin out and trim up the trees, and if possible mulch them. I will not cultivate the orchard.

A MESSAGE FROM THE NORTH

By W. W. FARNSWORTH, Waterville

Whenever a body of men of kindred tastes, and following the same or similar avocations, come together for an interchange of experiences, great benefits are sure to follow.

Life is too short for the Horticulturist to secure the information necessary for the highest success through his own experience, and he who attempts it will find old age creeping on him before he has well mastered the rudiments.

The wise fruit grower is he who avails himself of the light which science and practise can give him, and by careful observation adapts these deductions to his individual needs.

Commercial and Domestic Horticulture have undergone great changes in the last score of years.

Twenty years ago nearly every farmer grew his own supply of fruit and usually had a surplus, which was thrown upon the market in any condition, in any package, at any price.

Unfortunately for the grower for home use only, but fortunately for the professional grower, these conditions have radically changed. The increased number of insect and fungous enemies and especially the advent of what Hale calls “That blessed San Jose scale” has given the field into the hands of the professional grower who is willing and able to equip himself with the necessary knowledge and appliances, and who will make a study of the business and make all others secondary or contributory.

One thing which has greatly retarded the progress of fruit growing, has been a tendency to copy blindly the methods of others or to follow dogmatic rules formulated by other fruit growers more or less successful.

We may and should learn much from others, but all plans and recommendations must be tested carefully and thoughtfully under our own conditions before being accepted as being applicable to our needs.

Prof. Roberts of Cornell when asked if certain dairy practices were commendable replied, ask the cow. And so when in doubt as to the wisdom of any contemplated method let us ask the trees.

In other words we must be close students and observers of our own business.

We can not lay down any ironclad rule of management which will apply to fruit trees under all conditions.

We must study the requirements of the tree.

Ask the tree what it requires and read its answer in the manner in which it responds to different treatments.

I believe there is a bright outlook for the Horticulturist in any part of Ohio who will push his business, and I believe that much of southeastern Ohio is particularly adapted to fruit growing.

A proper location is essential, but the proper man is even more so.

There are probably more fruit locations than fruit men.

To attain the highest measure of success and at the same time enjoy the greatest measure of satisfaction, we must like the business.

There are many little details which go to make the perfect orchard, and these will be attended to, only if we look upon each tree as a personal friend and acquaintance.

Individual practises in pruning have blazed a fairly plain trail which we may follow while studying how to do better, and observing the effects of different methods.

The science of spraying while yet in its infancy, has reached that stage where we stand on firm ground while we advance farther.

In the matter of feeding the tree, but little advance has been made because dame Nature has attended to that part of the work with but little of our help.

It is high time for us to begin to cooperate with her however. Nature produces fruits unaided, but with man's assistance she produces much better crops of much better fruits.

We should study the requirements of the tree and aim to secure the necessary food and moisture, by those means which under our conditions, will accomplish the end in the cheapest and most effective manner.

We can not say that all must cultivate, neither can we say that all should mulch. Conditions must govern.

Possibly the most general rule which can be given, is that all must spray, and spray thoroughly, if they wish to succeed.

But we can not say that all shall spray alike or that the same grower should spray two seasons alike.

The fruit grower on the "Sun Kissed" hills of Ohio must face the problem of moisture and fertility in a different manner from which we meet it on our stronger level lands.

The amount of fertility required to produce a dollar's worth of fruit, is much less however than that required to produce a dollar's worth of grain.

The necessary humus must usually be grown either in the orchard itself or on land adjoining.

Probably this will need to be supplemented by the use of commercial fertilizers although in some instances, the addition of sufficient humus, may render available a sufficient amount of the mineral elements already in the soil. A safe rule for the novice is to adopt the practises of the most successful growers, whose conditions are similar, and then not follow them blindly, but search out the reason for everything and always try to improve. Then the question of marketing the fruit is of great importance. People are more particular about the quality of their fruits than of most other products. While a bushel of the finest wheat may not sell in the market for more than 25 to 30 percent more than a bushel of number 3 yet a bushel of fancy peaches will bring three or four times as much as a bushel of the third grade. The masses are coming to recognize fruit as a luxurious necessity and want it not only of good quality but attractive in appearance, and he who places on the market just such an article as he himself would like to buy were he purchasing, will have no trouble in getting and keeping customers. The manner of marketing as well as the varieties to plant will depend upon conditions. If you have good shipping facilities to a good market and are making fruit growing your main business, you will do well to plant a succession of varieties and arrange to supply grocers

or consumers during the entire season, thus securing a good trade and distributing the labor of harvesting and marketing over a long season. If however you have not these advantages, or if fruit growing is but a side issue with you, you will do better to grow but few varieties and sell at wholesale.

To recapitulate. Don't go into the fruit business simply because you think there is money in it. You must love it to succeed. Take a personal interest in every tree and plant. Cooperate with nature to feed and water the tree in the cheapest way you can and still secure the greatest possible amount of fine fruit, for the largest number of years. Prune intelligently or in other words be able to give a reason for every limb you cut off. Spray diligently and know what every application is for and examine carefully to see if it accomplishes the desired end.

Do not plan too large an acreage. Market in accordance with the Golden rule and remember that a pleased customer is the best advertisement.

Ohio Agricultural Experiment Station

CIRCULAR No. 104.

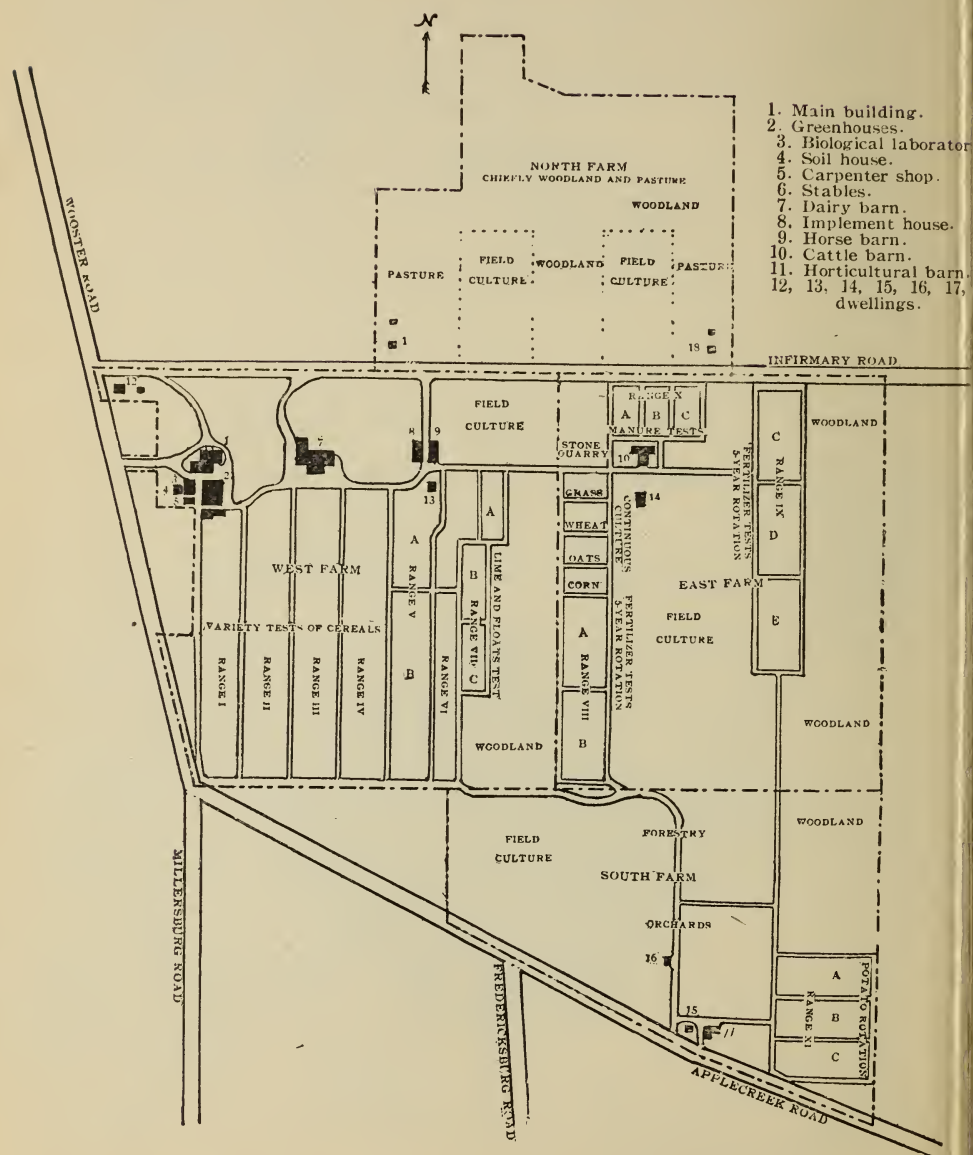
WOOSTER, OHIO, AUGUST 15, 1910

PLANS AND SUMMARY TABLES
OF THE EXPERIMENTS AT THE CENTRAL FARM, WOOSTER,
ON THE
MAINTENANCE OF SOIL FERTILITY.
ARRANGED FOR REFERENCE IN THE FIELD.

ANNOUNCEMENT

The experiments reported in the following pages were begun in 1893, immediately after the removal of the Experiment Station to Wayne county. The general plan of this work and the results obtained up to that time are published in Bulletin 110, issued in December, 1899, (now out of print) and again in Bulletins 182, 183, and 184, reporting to the end of 1906. It now seems desirable to follow these general publications with an annual statement, giving as briefly as possible the new data obtained from each successive crop, and referring the reader to Bulletins 182 and 183 for more complete information respecting the nature of the soils under experiment and the general plan of the work.

The results for 1907 are given in Circular No. 83, and those for 1908 in Circular No. 92.



The central farm, near Wooster.

FERTILIZERS AND MANURE ON CROPS GROWN CONTINUOUSLY ON THE SAME LAND

Wheat, oats and corn, one acre (10 plots) each, have been grown in this experiment since 1894. The fertilizers are applied to Plots 2 and 8 in arbitrary quantities, while on Plots 3 and 9 the three fertilizing elements, nitrogen, phosphorus and potassium, are given in approximately the same ratio to each other in which they are found in the plant.

The applications to Plots 2 and 8 have in every case produced larger yields than those to Plots 3 and 9, but this may in part be accounted for by the combined nitrogen which is carried to the soil in rain, thus enabling the crops grown on 2 and 8 to utilize larger quantities of the phosphorus and potassium given in the fertilizer than that required merely to balance the fertilizer nitrogen.

The manure applications on Plots 5 and 6 were intended to carry nitrogen in quantities equivalent to the applications on Plots 2 and 3 on the one hand and 8 and 9 on the other, estimating the manure to carry 10 pounds of nitrogen per ton, but actual analyses of manure, made during recent years, indicate that this estimate was too high for open yard manure, such as is used in these tests. The average application of phosphorus and potassium in the manure closely approximates the average given to the four fertilized plots.

In this test the corn and wheat show a rapid falling off in yield on the unfertilized land during recent years. The oats also show a reduction in yield, but not so great as that of the other crops.

It is much more difficult to control the weed growth in the wheat and oats grown continuously than where the same crops are grown in rotation, and it was necessary a few years ago to divide these tracts and fallow the two ends in alternate seasons in order to destroy the weeds. Latterly the entire plots have been cropped again.

Diagram I shows the arrangement of plots and plan of fertilizing in this experiment, and the general outcome is shown in Tables I and II, which give the yields by periods.

DIAGRAM 1: PLAN OF FERTILIZING IN CONTINUOUS CULTURE

PLOTS ONE-TENTH ACRE

Fertilizing materials in pounds per acre

Wheat

- | | |
|----|---|
| 1 | None. |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160. |
| 3 | Acid phos., 60; muriate potash, 30; nitrate soda, 160. |
| 4 | None. |
| 5 | Yard manure, 2½ tons. |
| 6 | Yard manure, 5 tons. |
| 7 | None. |
| 8 | Acid phos., 160; muriate potash, 100; nitrate of soda, 320. |
| 9 | Acid phos., 120; muriate potash, 60; nitrate of soda, 320. |
| 10 | None. |

Oats

- | | |
|----|--|
| 1 | None. |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160. |
| 3 | Acid phos., 55; muriate potash, 50; nitrate soda, 160. |
| 4 | None. |
| 5 | Yard manure, 2½ tons. |
| 6 | Yard manure, 5 tons. |
| 7 | None. |
| 8 | Acid phos., 160; muriate potash, 100; nitrate soda, 320. |
| 9 | Acid phos., 110; muriate potash, 100; nitrate soda, 320. |
| 10 | None. |

Corn

- | | |
|----|--|
| 1 | None. |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160. |
| 3 | Acid phos., 45; muriate potash, 30; nitrate soda, 160. |
| 4 | None. |
| 5 | Yard manure, 2½ tons. |
| 6 | Yard manure, 5 tons. |
| 7 | None. |
| 8 | Acid phos. 160; muriate potash, 100; nitrate soda, 320. |
| 9 | Acid phos., 90; muriate potash, 60; nitrate soda, 320. |
| 10 | None. |

(South)

TABLE I: CROPS GROWN IN CONTINUOUS CULTURE. Yield and increase per acre for 1909 and average annual yield for 16 years 1894 to 1909

Plot No.	Fertilizing materials Pounds per acre	1909				16 years, 1894 to 1909				Plot No.
		Yield		Increase		Yield		Increase		
		Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	
Corn										
1	None	14.90	1,910	20.00	1,463	22.22	1,441	22.08	949	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	31.79	3,220	20.75	897	42.71	2,326	15.90	634	2
3	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	29.43	2,500	20.75	897	34.95	1,946	15.90	634	3
4	None	5.57	1,450			17.46	1,248			4
5	Yard manure, 2½ tons.	15.68	2,100	9.79	730	28.92	1,761	11.92	529	5
6	Yard manure, 5	25.86	2,650	19.64	1,360	38.45	2,124	21.90	909	6
7	None	6.54	1,210	46.53	2,013	16.07	1,199	32.45	1,226	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320.	52.50	3,260	43.82	1,857	47.51	2,376	31.10	1,146	8
9	Acid phosphate, 120; muriate potash, 60; nitrate soda, 320.	49.21	3,140	43.82	1,857	45.15	2,246	31.10	1,146	9
10	None	4.82	1,320			13.03	1,051			10
	Average unfertilized yield	7.96	1,473			18.15	1,252			
Oats										
1	None	16.72	895	21.49	1,482	21.05	783	20.64	1,065	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	38.44	2,370	19.53	1,275	42.34	1,877	16.20	801	2
3	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	36.72	2,155	19.53	1,275	38.55	1,642	16.20	801	3
4	None	17.42	873			23.00	871			4
5	Yard manure, 2½ tons.	26.88	1,440	9.28	533	31.17	1,220	7.93	314	5
6	Yard manure, 5	36.64	2,228	18.85	1,287	38.44	1,706	14.97	765	6
7	None	17.97	975			23.72	977			7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320.	46.57	3,180	28.05	2,139	48.38	2,419	24.27	1,439	8
9	Acid phosphate, 110; muriate potash, 100; nitrate soda, 320.	45.55	3,093	26.49	1,986	46.57	2,275	22.08	1,293	9
10	None	19.61	1,173			24.88	985			10
	Average unfertilized yield	17.93	979			23.44	909			
Wheat										
1	None	10.01	1,178	17.05	2,637	8.24	1,104	11.77	1,460	1
2	Acid phos., 45; mur. potash, 100; nit. soda, 120; dried blood, 50	27.25	3,829	13.25	1,521	20.17	2,529	7.47	861	2
3	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	23.65	2,726	13.25	1,521	16.02	1,896	7.47	861	3
4	None	10.59	1,219	11.98	1,319	8.70	1,000	5.17	696	4
5	Yard manure, 2½ tons.	22.49	2,554	11.98	1,319	13.83	1,705	5.17	696	5
6	Yard manure, 5	28.24	3,159	17.80	1,909	17.93	2,206	9.30	1,188	6
7	None	10.36	1,266	22.42	3,440	8.60	1,027	14.57	1,938	7
8	Acid phos., 160; mur. potash, 100; nit. soda, 200; dried blood, 50	31.77	4,546	22.42	3,440	22.87	2,922	14.57	1,938	8
9	Acid phosphate, 90; mur. potash, 100; nit. soda, 200; dried blood, 50	30.19	3,919	21.84	2,974	20.82	2,491	12.82	1,550	9
10	None	7.34	785			7.70	897			10
	Average unfertilized yield	9.58	1,112			8.31	1,007			

THE 5-YEAR ROTATION

In this experiment corn, oats, wheat, clover and timothy are grown in succession on five tracts of land, A, B, C, D and E, containing 30 one-tenth acre plots each. Sections A and B of this test lie in range VIII, south of the areas devoted to continuous cropping, while sections C, D and E occupy Range IX, near the east side of the farm.

The land was underdrained in 1893, and corn was grown that season on section C. The planting was delayed by the draining and the season proved unfavorable, so that the results of that season's work have not been included in the average. In 1894 wheat was harvested on section A, oats on section C and corn on section D. The clover and timothy followed the wheat on section A in 1895 and 1896, and the rotation has since been regularly followed.

Beginning with 1900, lime was applied to the west half of each plot in this rotation, fertilized and unfertilized alike, while the land was being prepared for corn, the lime being applied at the rate of one ton per acre of ground quicklime in 1900, 1901, 1902 and 1903, applied in the spring after plowing, and in the fall of 1903 for the crop of 1904. In 1905 the liming was changed to the east half, a ton of quicklime being used that spring, but in 1906 and 1907 ground limestone was used, at the rate of two tons per acre. No lime was applied in 1908. The table gives the average yield for the entire plot in each case, averaging the limed and unlimed halves.

In 1895 and 1896, and again in 1899, 1900 and 1901 the wheat in this test was injured by Hessian fly, the yield on the unfertilized land falling to a small fraction over one bushel per acre in 1896 and 1900.

Diagram II shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the five sections being arranged and treated exactly alike. Tables III and IV give the yields per acre for 1909 and for the average of the 16 years, and Table V shows the general results by periods.

TABLE III: CROPS GROWN IN 5-YEAR ROTATION

Yield and increase per acre, 1909. Total fertilizing elements per acre for one rotation.

Plot No.	Fertilizing element			Corn		Oats		Wheat		Hay		Plot No.
	Nitrogen Lbs.	Phosphorus Lbs.	Potassium Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	Clover Lbs.	Timothy Lbs.	
Yield per acre												
1	...	...	...	24.07	2,190	35.55	2,043	18.92	1,695	5,326	The timothy crop was a failure in 1909	1
2	...	20	...	27.93	1,870	48.98	2,753	29.92	2,655	5,484		2
3	...	...	108	24.32	2,440	40.31	2,730	25.25	2,575	4,987		3
4	...	...	...	20.32	1,800	35.79	2,265	24.00	2,020	4,312		4
5	76	...	...	26.18	2,110	39.77	2,338	25.54	2,528	4,605		5
6	76	20	...	29.57	1,820	54.46	3,308	34.25	3,785	5,377		6
7	...	...	...	13.46	1,530	33.83	2,348	20.50	1,890	4,315		7
8	...	20	108	31.46	2,040	50.08	2,858	31.13	3,163	5,626		8
9	76	...	108	30.00	2,420	51.57	3,060	24.71	2,708	4,826		9
10	...	...	...	20.78	1,740	34.07	2,230	20.17	2,020	3,333		10
11	76	20	108	38.25	2,680	53.60	3,455	34.17	4,200	6,506		11
12	112	20	108	43.07	2,640	54.61	3,113	31.00	3,950	6,595		12
13	...	...	...	12.25	1,340	33.53	1,808	21.54	2,168	4,791		13
14	50	15	74	29.04	2,080	45.63	2,250	34.58	4,065	6,160		14
15	25	10	41	25.04	2,230	36.17	1,898	32.88	4,008	5,609		15
16	...	...	...	17.64	1,680	33.13	2,050	21.29	1,973	3,546		16
17	38	30	108	45.07	2,800	59.93	3,443	33.13	3,943	5,546		17
18	144	48	112	57.36	3,000	51.10	3,015	33.58	4,185	5,973		18
19	...	...	...	24.07	1,980	33.98	2,043	22.84	2,300	3,671		19
20	72	24	56	43.11	2,620	45.39	2,818	33.21	3,418	4,587		20
21	38	30	108	46.11	2,770	53.20	3,038	32.83	4,010	5,981	21	
22	...	...	...	22.18	1,990	36.64	2,228	21.55	2,078	3,307	22	
23	38	30	108	40.93	2,450	57.58	3,248	32.13	3,843	5,200	23	
24	...	...	...	30.50	2,270	59.61	3,103	32.67	3,850	6,160	24	
25	...	...	...	22.25	1,990	35.71	2,048	22.38	2,328	4,044	25	
26	76	20	108	33.67	2,670	55.24	3,373	32.79	3,983	5,955	26	
27	76	20	108	42.07	2,800	51.41	3,265	32.84	4,280	5,591	27	
28	...	...	...	14.18	1,740	47.66	3,255	20.67	2,080	3,288	28	
29	76	20	108	29.00	2,560	52.58	3,608	31.67	4,100	5,404	29	
30	38	30	108	39.96	2,450	58.44	3,310	30.71	3,458	5,858	30	
Average unfertilized yield				19.08	1,798	36.02	2,232	21.38	2,055	3,993		
Increase per acre												
2	...	20	...	5.11	-190	13.35	636	9.32	852	496		2
3	...	...	108	2.75	510	4.60	539	2.94	662	337		3
5	76	...	...	8.15	400	4.63	45	2.71	551	292		5
6	76	20	...	13.82	200	19.98	988	12.58	1,852	1,063		6
8	...	20	108	15.56	440	16.17	549	10.74	1,230	1,638		8
9	76	...	108	11.65	750	17.58	791	4.43	731	1,166		9
11	76	20	108	20.31	1,073	19.61	1,366	13.54	2,131	2,687		11
12	112	20	108	27.97	1,167	20.70	1,164	9.92	1,831	2,290		12
14	50	15	74	14.99	627	12.03	361	13.12	1,962	1,784		14
15	25	10	41	9.20	663	2.81	-71	11.51	1,970	1,648		15
17	38	30	108	25.29	1,020	26.52	1,395	11.32	1,861	1,958		17
18	144	48	112	35.43	1,120	17.40	970	11.26	1,994	2,344		18
20	72	24	56	19.67	637	10.52	713	10.80	1,192	1,037		20
21	38	30	108	23.30	783	17.45	872	10.85	1,858	2,553		21
23	38	30	108	18.73	460	21.25	1,080	10.30	1,682	1,647		23
24	38	30	108	8.27	280	23.59	995	10.57	1,605	2,362		24
26	76	20	108	14.11	763	15.55	923	10.98	1,738	2,163		26
27	76	20	108	25.20	977	7.73	412	11.60	2,117	2,051		27
29	76	20	108	14.82	820	4.92	353	11.00	2,020	2,116		29
30	38	30	108	25.78	710	10.78	55	10.04	1,378	2,570		30

The timothy crop was a failure in 1909

TABLE IV: CROPS GROWN IN 5-YEAR ROTATION

Average annual yield and increase per acre for the 16 years, 1894-1909

Plot No.	Fertilizing Elements			Corn		Oats		Wheat		Hay		Plot No.
	Nitro- gen Lbs.	Phos- phorus Lbs.	Potas- sium Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	Clover Lbs.	Tim- othy Lbs.	
Yield per acre												
1	...	...	...	31.24	1,697	32.77	1,359	10.95	1,164	2,069	2,853	1
2	...	20	...	38.70	1,889	40.79	1,654	19.10	1,902	2,629	3,079	2
3	...	...	108	35.46	1,956	35.88	1,469	12.80	1,357	2,367	2,915	3
4	...	...	...	30.65	1,664	31.89	1,335	11.64	1,174	2,109	2,734	4
5	76	...	...	35.69	1,849	35.95	1,472	13.57	1,490	2,419	3,138	5
6	76	20	...	44.94	2,005	47.00	1,938	24.70	2,539	3,168	3,438	6
7	...	...	...	31.05	1,648	31.43	1,302	11.42	1,171	1,997	2,578	7
8	...	20	108	44.25	2,173	43.15	1,813	20.37	1,929	2,944	3,046	8
9	76	...	108	36.26	1,937	37.19	1,586	14.21	1,519	2,375	2,931	9
10	...	...	...	29.47	1,589	31.74	1,293	11.32	1,129	1,935	2,515	10
11	77	20	108	47.80	2,298	50.09	2,236	27.48	2,930	3,365	3,582	11
12	112	20	108	48.36	2,310	49.24	2,285	28.16	2,992	3,469	3,474	12
13	...	...	...	29.84	1,636	31.55	1,332	11.46	1,168	1,979	2,556	13
14	50	15	74	44.82	2,200	39.31	1,688	25.84	2,723	3,005	3,210	14
15	25	10	41	35.15	1,998	32.58	1,338	24.56	2,550	2,580	2,910	15
16	...	...	...	27.96	1,650	29.72	1,222	10.24	1,006	1,772	2,446	16
17	38	30	108	47.03	2,440	48.18	2,208	22.79	2,319	3,094	3,186	17
18	144	48	112	51.11	2,605	39.63	1,822	21.36	2,324	3,822	4,014	18
19	...	...	...	31.81	1,751	30.93	1,301	11.04	1,127	1,912	2,574	19
20	72	24	56	44.03	2,202	37.47	1,639	17.89	1,909	2,936	3,446	20
21	38	30	108	46.79	2,286	44.21	1,998	23.98	2,507	2,875	3,050	21
22	...	...	...	28.56	1,683	30.29	1,258	10.64	1,055	1,653	2,306	22
23	38	30	108	46.53	2,266	47.52	2,086	22.80	2,290	2,787	3,022	23
24	...	...	...	46.61	2,287	48.98	2,276	23.39	2,363	2,964	2,948	24
25	...	...	...	31.37	1,764	31.61	1,358	11.62	1,204	1,941	2,611	25
26	76	20	108	46.08	2,341	47.24	2,058	26.77	2,473	3,483	3,637	26
27	76	20	108	47.84	2,337	49.48	2,232	29.68	2,742	3,086	3,449	27
28	...	...	...	32.99	1,828	33.47	1,392	11.25	1,078	2,014	2,847	28
29	76	20	108	48.06	2,419	47.74	2,112	25.05	2,617	3,231	3,797	29
30	38	30	108	47.22	2,248	44.61	1,929	22.52	2,203	3,247	3,743	30
Average unfertilized yield				30.49	1,691	31.54	1,317	11.17	1,129	1,938	2,602	
Increase per acre												
2	...	20	...	7.66	204	8.31	303	7.92	735	546	266	2
3	...	...	108	4.61	281	3.70	126	1.39	187	271	141	3
5	76	...	...	4.91	190	4.22	148	2.02	318	347	456	5
6	76	...	...	14.02	352	15.42	625	13.20	1,367	1,134	809	6
8	...	20	108	13.73	544	11.62	514	8.98	772	968	490	8
9	76	...	108	6.28	326	5.55	290	2.85	377	419	396	9
11	76	20	108	18.21	693	18.41	930	16.12	1,789	1,415	1,053	11
12	112	20	108	18.64	690	17.62	965	16.75	1,838	1,505	931	12
14	50	15	74	15.61	559	8.37	394	14.78	1,609	1,094	691	14
15	25	10	41	7.87	269	3.32	78	13.92	1,490	739	427	15
17	38	30	108	18.23	644	18.05	959	12.29	1,274	1,275	697	17
18	144	48	112	20.97	773	11.16	547	10.59	1,238	1,957	1,482	18
20	72	24	56	13.31	474	6.76	352	6.98	806	1,110	961	20
21	38	30	108	17.14	580	15.57	785	13.21	1,428	1,136	655	21
23	38	30	108	17.04	556	16.79	795	11.83	1,185	1,037	614	23
24	38	30	108	16.18	550	17.81	951	12.09	1,209	1,118	439	24
26	76	20	108	14.17	555	15.02	689	12.58	1,310	1,518	946	26
27	76	20	108	15.39	530	16.63	851	15.40	1,622	1,097	681	27
29	76	20	108	15.07	591	14.27	720	13.80	1,538	1,217	950	29
30	38	30	108	14.23	420	11.15	537	11.26	1,125	1,233	896	30

TABLE V: TOTAL FERTILIZING MATERIALS AND THEIR COST, AND TOTAL AND NET VALUE OF INCREASE PRODUCED FOR 5-YEAR PERIODS AND FOR 16 YEARS, ALL CALCULATED FOR ONE ROTATION OF 5 YEARS

Plot No.	Fertilizing materials in pounds per acre for each rotation	Cost of fertilizers for each rotation	Average value of total increase per acre for each rotation				Net gain or loss (—) from fertilizers for each rotation				Plot No.
			First 5-years	Second 5-years	Third 5-years	16-year average Total	First 5-years	Second 5-years	Third 5-years	16-year average Net	
2	Acid phosphate, 320.....	\$ 2.60	\$ 8.50	\$17.37	\$24.32	\$16.48	\$ 5.90	\$14.77	\$21.72	\$13.88	2
3	Muriate potash, 260.....	6.50	5.19	4.67	9.17	6.40	—1.31	—1.83	2.67	—1.40	3
5	Nitrate Soda, 440; dried blood, 50.....	14.40	4.70	10.40	9.03	8.80	—9.70	—4.00	—5.37	—5.60	5
6	Acid phosphate, 320; nitrate soda, 440; dried blood, 50.....	17.00	19.09	35.37	39.75	31.09	2.09	18.27	22.75	14.09	6
8	Acid phosphate, 320; muriate potash, 260.....	9.10	14.40	24.37	33.51	10.35	5.30	15.27	24.41	15.00	8
9	Muriate potash, 260; nitrate soda, 440; dried blood, 50.....	20.90	5.85	11.35	13.23	10.95	—15.05	—9.55	—6.67	—9.95	9
11	Acid phos., 320; mur. potash, 260; nit. soda, 440; dried blood, 50.....	23.50	26.39	42.43	49.96	39.33	2.80	18.93	26.46	15.83	11
12	Acid phos., 320; mur. potash, 180; nit. soda, 280; dried blood, 50.....	30.70	26.16	45.53	48.24	39.72	2.54	14.83	17.54	9.02	12
14	Acid phos., 240; mur. potash, 180; nit. soda, 280; dried blood, 50.....	16.05	21.37	32.91	37.33	30.56	—4.54	15.85	21.28	14.51	14
15	Acid phos., 160; mur. potash, 100; nit. soda, 120; dried blood, 50.....	8.60	13.89	22.86	27.13	21.91	5.29	14.26	18.53	13.31	15
17	Acid phos., 480; mur. potash, 260; nit. soda, 220; dried blood, 25.....	17.60	15.74	36.61	46.28	33.63	—1.86	19.01	28.68	16.03	17
18	Yard manure, 16 tons.....	?	19.82	34.24	55.94	36.91	?	?	?	?	18
20	Yard manure, 8 tons.....	?	13.02	21.28	35.36	23.09	?	?	?	?	20
21	Same elements as 17, but nitrogen in oilmeal.....	17.60	20.43	36.25	42.24	32.34	2.83	18.65	24.64	14.74	21
23	Same elements as 17, but nitrogen in dried blood.....	17.60	19.09	34.37	39.28	30.73	1.49	16.77	21.68	13.13	23
24	Same elements as 17, but nitrogen in sulphate ammonia.....	17.60	20.70	32.77	38.71	30.69	3.10	14.77	21.11	13.09	24
26	Same elements as 11, but phosphorus in bone meal.....	23.50	20.89	36.17	42.55	32.92	—2.61	12.67	19.05	9.42	26
27	Same elements as 11, but phosphorus in dissolved boneblack.....	23.50	19.86	39.85	42.08	33.84	—3.64	16.38	18.58	10.34	27
29	Same elements as 11, but phosphorus in basic slag.....	23.50	21.91	39.32	39.04	33.16	—1.39	15.82	15.54	9.66	29
30	Same elements as 17, but nitrogen in tankage.....	*17.60	13.74	30.51	41.62	25.45	....	12.90	24.02	10.85	30

The nearest practicable approach to a common denominator for the various kinds of produce grown in this rotation is their market value, and in Table V the results of the test are arranged on this basis for three 5-year periods and for the entire 16 years, corn being rated at 40 cents per bushel, oats at 30 cents, wheat at 80 cents, hay at \$3.00 per ton, stover at \$3.00 and straw at \$2.00; valuations much below present prices for the grains, but not far from the average values during the period of the test.

The fertilizing materials are valued at a fraction over \$16.00 per ton for acid phosphate, 2½ cents per pound for muriate of potash and 3 cents per pound for nitrate of soda; and it is assumed that the cost per pound of the fertilizing elements will be practically the same in the other carriers used on Plots 21 to 30 inclusive.

The table shows that the effectiveness of the fertilizers and manure has increased with each successive period, the greatest relative increase being shown by the manure. Taking the second part of the table, giving the net gain after deducting the cost of the fertilizers, it will be seen that during the first period eight of the fertilizer applications failed to produce sufficient increase to cover their cost; during the second period three, and during the third period two. Every complete fertilizer has been used with a profit since the first period, but when either nitrate of soda or muriate of potash has been used unaccompanied by some carrier of phosphorus there has been a loss in each period and in the average of the 16 years.

Nevertheless, both nitrogen and potassium are essential to the highest net profit, as shown by comparing Plot 2, receiving phosphorus only, with Plot 8, receiving potassium in addition and Plot 11, receiving these with nitrogen.

The results of the comparison of different carriers of nitrogen and phosphorus have been discussed in Circular No. 93.

*For last 2 periods.

THE POTATOES-WHEAT-CLOVER ROTATION

This experiment is located on the South farm, southeast of the orchards, and contains three sections of 34 plots each. The south section (A) and about half of the middle section (B) had been in cultivation for an unknown period before the test began. The north part of section B and all of the north section (C) were cleared from the forest for the purposes of this test. The old land was tile drained in 1893 and the work was begun by planting Section A to potatoes in 1894. Wheat and clover followed in 1895 and 1896 and the rotation has been maintained regularly since.

The potato crops in this test have in some seasons been somewhat injured by blight, and in 1904 a dashing rain, coming just after the potatoes had been planted, washed much of the seed out of the ground. These difficulties have caused an irregular stand, and for this reason the results have been "corrected" on the basis of the average stand obtained on the unfertilized plots. Both actual and "corrected" yields are given in the table. In 1909 the potatoes were reduced to about one-third the average crop by a combined attack of white grub and *Fusarium* wilt, the latter causing the larger part of the injury.

In 1895 and 1896 the wheat in this test was severely injured by Hessian fly, but it escaped the attack of 1899 to 1901.

In 1900 the clover failed; attempts were made to grow crimson clover and soybeans in its stead, but there was failure in securing a stand of these crops also, so that it has been necessary to omit that season from the calculations. In 1905 continuous rains prevented harvesting the clover until very late, and caused the fertilized plots to lodge, so that these plots weighed less than those not fertilized, though earlier in the season they had shown a distinctly stronger growth. As there was no way by which the yields could be corrected and as it seemed desirable to include the crop in the general average because of its effect on the average unfertilized yield it has been so included, although the doing so slightly reduces the apparent average effect from the fertilizers.

Diagram III shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the three sections being arranged and treated alike. Tables VI and VII give the yield per acre for 1909 and for the 16 years, 1894-1909.

PLOTS ONE-TENTH ACRE
Fertilizing materials in pounds per acre

[illegible]

CROPS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER

TABLE VI: Yield per acre 1909, and average for 16 years, 1894-1909

Fertilizing elements for each rotation

Plot No.	Fertilizing elements			Potatoes		Wheat				Clover		Plot No.
	Nitro- gen Lbs.	Phos- phorus Lbs.	Potas- sium Lbs.	1909 Bus. (actual)	16-yr. av. Bus.	1909		15-year average		1909 Lbs.	14-yr. av. Lbs.	
						Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.			
1	...	...	...	64.32	159.57	34.37	4,137	31.14	3,209	5,564	4,260	1
2	...	20	...	46.83	174.15	40.33	5,140	36.61	3,837	6,193	4,484	2
3	...	...	83	70.77	172.04	39.29	4,422	33.12	3,100	6,791	4,128	3
4	...	...	...	55.39	163.66	40.17	4,270	31.15	3,060	5,724	3,845	4
5	38	...	...	60.78	168.32	41.17	4,370	31.42	3,278	6,658	4,131	5
6	38	20	...	61.09	175.14	43.25	5,445	36.88	3,922	7,093	4,286	6
7	...	...	...	33.23	149.72	38.50	3,970	29.08	2,840	4,516	3,781	7
8	...	20	83	94.33	183.16	40.21	3,947	36.34	3,390	5,982	4,064	8
9	38	...	83	89.25	166.63	45.62	4,802	35.20	3,321	5,831	4,277	9
10	...	...	...	40.41	152.81	40.71	4,077	30.32	2,831	4,382	3,647	10
11	38	20	83	86.33	177.97	43.54	5,507	38.94	3,839	6,596	4,159	11
12	50	20	83	92.50	185.10	43.54	5,827	38.72	3,984	7,200	4,377	12
13	...	...	...	31.83	151.14	42.00	4,320	29.69	2,777	4,756	3,787	13
14	50	30	124	110.83	186.45	43.67	6,180	38.64	3,961	6,649	4,322	14
15	50	30	124	100.17	182.34	44.87	5,357	37.33	3,639	6,311	4,303	15
16	...	...	...	34.50	141.34	41.33	3,980	28.16	2,551	4,124	3,531	16
17	36	12	28	64.58	152.39	44.46	4,792	32.20	3,167	5,591	4,146	17
18	72	24	56	61.08	156.36	43.79	4,872	33.26	3,245	6,933	4,544	18
19	...	...	...	46.67	139.46	38.12	3,622	25.37	2,464	3,822	3,257	19
20	25	20	83	88.25	182.45	44.33	5,190	34.65	3,422	5,840	4,097	20
21	25	20	83	74.09	173.81	44.04	4,977	34.78	3,316	4,622	3,689	21
22	...	...	...	49.31	141.97	38.67	3,620	25.07	2,278	3,671	3,323	22
23	25	20	83	83.83	169.97	43.50	5,430	35.46	3,368	5,218	3,759	23
24	25	20	83	88.92	177.11	43.75	4,755	35.44	3,296	5,147	3,747	24
25	...	...	...	45.75	141.18	36.37	3,867	25.51	2,380	3,849	3,361	25
26	38	20	83	90.58	171.11	42.96	4,862	36.13	3,452	6,178	4,122	26
27	38	20	83	88.92	177.10	42.96	5,382	37.35	3,747	5,867	3,919	27
28	...	...	...	56.00	143.58	35.12	3,172	25.57	2,479	4,258	3,499	28
29	38	20	83	99.42	175.79	40.50	4,270	37.80	3,772	6,898	4,405	29
30	72	24	56	104.33	187.67	42.12	4,152	32.53	3,158	5,840	4,305	30
31	...	...	...	39.42	148.87	33.92	3,355	25.42	2,468	4,658	3,410	31
32	144	48	112	113.92	175.96	42.75	5,685	39.10	3,990	7,351	4,196	32
33	25	20	83	78.17	167.20	42.33	4,220	39.02	3,620	5,984	3,356	33
34	...	...	...	39.33	132.74	34.37	3,517	27.49	2,565	4,676	2,877	34
Average unfertilized yield				44.68	147.69	37.80	3,826	27.41	2,628	4,500	3,601	

TABLE VII. Increase per acre, and annual average for 16 years, 1894-1909

Cost of fertilizer for 1 rotation and 16-year average value of increase for each rotation

Plot No.	Potatoes		Wheat				Clover		Cost of ferti- lizer	Value of increase for one rotation		Plot No.
	1909 Bus. (actual)	16-yr. av. Bus.	1909		15-year average		1909 Lbs.	14-yr. av. Lbs.		Total	Net	
			Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.						
2	-14.51	13.21	4.03	959	5.49	677	579	364	\$ 2.60	\$11.81	\$ 9.21	2
3	12.40	9.70	1.05	196	1.98	-9	1,120	145	5.00	6.03	1.03	3
5	12.78	9.31	1.56	200	.96	292	1,337	308	7.20	6.02	-1.18	5
6	20.47	20.77	4.19	1,375	7.11	1,009	2,174	484	9.80	16.94	7.94	6
8	58.71	32.41	.97	-59	6.85	552	1,511	328	7.60	20.31	12.71	8
9	51.23	14.85	5.65	761	5.29	487	1,404	586	12.20	13.00	.80	9
11	48.78	25.74	2.40	1,349	8.83	1,026	2,089	466	14.80	20.25	5.45	11
12	57.81	33.41	1.97	1,588	8.82	1,189	2,569	637	19.60	24.16	4.56	12
14	78.11	38.55	1.89	1,973	9.46	1,259	2,104	621	21.00	26.73	5.73	14
15	66.56	37.69	3.32	1,264	8.66	1,012	1,976	687	21.00	25.76	4.76	15
17	26.02	15.61	3.87	932	4.97	645	1,568	707	?	13.69	?	17
18	18.47	20.90	3.93	1,131	6.92	752	3,010	1,196	?	19.43	?	18
20	40.70	42.16	6.03	1,569	9.38	1,021	2,068	818	12.40	28.66	16.26	20
21	25.66	32.68	5.55	1,356	9.61	976	901	388	12.40	23.29	10.89	21
23	35.71	28.17	5.60	1,728	10.24	1,056	1,488	423	12.40	22.21	9.81	23
24	41.98	35.66	6.61	970	10.07	950	1,357	398	12.40	24.86	12.46	24
26	41.41	29.13	7.01	1,227	10.60	1,039	2,193	712	14.80	24.02	9.22	26
27	36.34	34.32	7.42	1,978	11.80	1,302	1,745	467	14.80	26.34	11.54	27
29	48.95	30.45	5.78	1,037	12.28	1,297	2,507	935	14.80	27.04	12.24	29
30	59.38	40.56	7.80	858	7.06	686	1,315	866	?	26.02	?	30
32	74.53	45.80	8.68	2,276	10.90	1,295	2,687	1,229	?	33.32	?	32
33	38.81	31.42	8.11	769	11.22	990	1,314	448	12.40	24.33	11.93	33

BARNYARD MANURE TEST

COMPARISON OF YARD WITH FRESH MANURE

THE REINFORCEMENT OF MANURE

This experiment was begun in 1897 for the purpose of comparing manure which has lain for some months in an open barnyard with that taken directly from the stable to the field, and of studying the effect of treating the manure with several absorbent or reinforcing materials.

In this investigation a lot of manure has been taken from the open barnyard, where it has been accumulating during the winter, and divided into four parcels. With one parcel is mixed the finely ground, phosphatic rock, known as floats, from which acid phosphate is made by mixing it with sulphuric acid; with another parcel acid phosphate is mixed; with a third, the crude potash salt, known as kainit, and with a fourth, land plaster or gypsum; the reinforcing materials being used at the uniform rate of 40 pounds per ton of manure. At the same time manure taken from box stalls, where it has accumulated under the feet of animals kept continuously in their stalls, is divided into similar parcels and treated with like quantities of the same materials.

After a few weeks the manure thus treated, together with two lots of untreated manure, one taken from the yard and one from the stable, is spread upon clover sod at the rate of eight tons per acre and plowed under for corn, the corn being followed by wheat and clover in a 3-year rotation. During the first three seasons soybeans were grown, because of clover failure, and were plowed under.

Three tracts of land, A, B and C, are included in the test, each crop being grown every season. The arrangement of these tracts and the plan of fertilizing are shown in Diagram IV, and the results are given in Tables VIII and IX.

**DIAGRAM IV: ARRANGEMENT OF PLOTS AND PLAN OF FERTILIZING IN
EXPERIMENTS WITH MANURE**

PLOTS ONE-SIXTEENTH ACRE

NORTH

SECTION A.

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

1	Nothing
2	Yard manure and floats
3	Stall manure and floats
4	Nothing
5	Yard manure and acid phos.
6	Stall manure and acid phos.
7	Nothing
8	Yard manure and kainit
9	Stall manure and kainit
10	Nothing

SECTION B.

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

1	Nothing
2	Yard manure and floats
3	Stall manure and floats
4	Nothing
5	Yard manure and acid phos.
6	Stall manure and acid phos.
7	Nothing
8	Yard manure and kainit
9	Stall manure and kainit
10	Nothing

SECTION C.

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

1	Nothing
2	Yard manure and floats
3	Stall manure and floats
4	Nothing
5	Yard manure and acid phos.
6	Stall manure and acid phos.
7	Nothing
8	Yard manure and kainit
9	Stall manure and kainit
10	Nothing

**DIAGRAM IV: ARRANGEMENT OF PLOTS AND PLAN OF FERTILIZING IN
EXPERIMENTS WITH MANURE**

PLOTS ONE-SIXTEENTH ACRE

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

SECTION A.

Nothing	1
Yard manure and floats	2
Stall manure and floats	3
Nothing	4
Yard manure and acid phos.	5
Stall manure and acid phos.	6
Nothing	7
Yard manure and kainit	8
Stall manure and kainit	9
Nothing	10

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

SECTION B.

Nothing	1
Yard manure and floats	2
Stall manure and floats	3
Nothing	4
Yard manure and acid phos.	5
Stall manure and acid phos.	6
Nothing	7
Yard manure and kainit	8
Stall manure and kainit	9
Nothing	10

11	Nothing
12	Yard manure and gypsum
13	Stall manure and gypsum
14	Nothing
15	Yard manure, untreated
16	Stall manure, untreated
17	Nothing
18	Chemical fertilizer
19	Chemical fertilizer
20	Nothing

SECTION C.

Nothing	1
Yard manure and floats	2
Stall manure and floats	3
Nothing	4
Yard manure and acid phos.	5
Stall manure and acid phos.	6
Nothing	7
Yard manure and kainit	8
Stall manure and kainit	9
Nothing	10

NORTH

TABLE VIII: BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION
Average yield per acre 1909 and 13 years 1897-1909

Plot No.	Manure and treatment	1909				13 years, 1897-1909				Plot No.
		Corn		Wheat		Clover		Corn 12 crops		
		Grain	Stover	Grain	Straw	Hay		Grain	Stover	
		Bus.	Lbs.	Bus.	Lbs.	Lbs.		Bus.	Lbs.	
Yield per acre										
1	None	25.92	2,480	20.27	1,952	6,058	37.15	2,222	2,781	1
2	Yard manure and floats	56.48	3,584	32.00	3,136	7,168	59.42	3,313	4,167	2
3	Stall manure and floats	65.60	3,616	33.33	3,360	7,794	63.31	3,565	4,768	3
4	None	7.84	1,472	21.13	2,092	4,139	31.03	2,009	2,049	4
5	Yard manure and acid phosphate	37.28	2,688	36.00	3,584	7,310	60.27	3,276	3,982	5
6	Stall manure and acid phosphate	36.48	2,880	33.33	3,376	7,452	64.38	3,471	4,687	6
7	None	96	736	16.80	1,920	4,750	30.83	1,970	2,683	7
8	Yard manure and kainit	15.02	1,920	24.13	2,456	6,386	54.63	3,154	3,362	8
9	Stall manure and kainit	38.56	2,944	23.07	2,840	6,770	60.07	3,495	4,206	9
10	None	17.28	1,920	15.27	1,836	5,006	32.89	2,003	1,305	10
11	None	14.80	1,760	22.53	2,360	6,400	36.83	2,353	1,730	11
12	Yard manure and gypsum	35.36	3,008	35.20	3,312	6,656	57.98	3,364	2,747	12
13	Stall manure and gypsum	42.72	3,328	32.80	3,072	6,656	60.66	3,550	2,747	13
14	None	5.31	1,216	20.73	2,054	4,522	31.57	2,007	2,689	14
15	Yard manure, untreated	25.76	2,400	31.60	3,000	5,945	51.17	2,886	1,283	15
16	Stall manure, untreated	43.68	3,104	32.27	3,088	6,130	58.16	3,304	2,249	16
17	None	2.72	1,088	23.60	2,632	4,594	36.55	2,303	2,405	17
18	Chemical fertilizer*	28.48	2,336	23.07	2,632	4,608	43.12	2,587	1,453	18
19	Chemical fertilizer†	28.64	2,400	21.73	2,632	4,537	44.37	2,456	1,686	19
20	None	26.24	2,144	16.07	1,852	4,693	34.09	2,025	1,341	20
Average unmanured yield		12.64	1,602	19.55	2,091	5,020	33.87	2,108	1,383	2,328

* Acid phosphate, 80 lbs.; muriate of potash, 80 lbs.; nitrate of soda, 160 lbs.

† Acid phosphate, 80 lbs.; muriate of potash, 10 lbs.; tankage (7-30), 100 lbs.

The corn in this test was injured by insects and bacterial disease in 1909, the injury amounting to an almost complete destruction of the crop on some of the unmanured plots. The manures enabled the corn in some degree to recover from the disaster, and in this respect the fresh manure has in general appeared to be superior to the yard manure, but because of the irregular injury it seems best to omit this crop from the general averages.

TABLE IX: BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION
Increase over average unmanured yield and its value (excluding corn crop of 1909)

Plot No.	Manure and treatment	Average annual increase per acre					Cost of treatment per acre	Value of increase	
		Corn 12 crops		Wheat 12 crops		Hay 9 crops		Total per acre	Net per ton of manure
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Lbs.			
2	Yard manure and floats	25.55	1,205	14.20	1,408	1,839	\$ 1.40	\$32.15	\$ 3.84
3	Stall manure and floats	29.44	1,458	15.59	1,602	2,440	1.40	37.80	4.55
5	Yard manure and acid phos. ..	26.40	1,168	14.81	1,463	1,634	2.40	32.16	3.72
6	Stall manure and acid phos. ..	30.51	1,363	15.36	1,589	2,359	2.40	37.56	4.40
8	Yard manure and kainit.	20.76	1,046	10.14	1,074	1,034	2.70	23.20	2.56
9	Stall manure and kainit.	26.20	1,387	11.92	1,387	1,878	2.70	31.00	3.20
12	Yard manure and gypsum	24.11	1,256	13.01	1,375	1,317	1.00	28.58	3.45
13	Stall manure and gypsum	26.79	1,442	12.66	1,332	1,341	1.00	29.70	3.59
15	Yard manure untreated	17.30	778	8.42	862	599	....	18.08	2.26
16	Stall manure untreated.	24.29	1,196	9.93	1,024	1,259	....	25.51	3.19
18	Chemical fertilizer ¹	9.25	471	2.83	309	599	7.45	9.37	....
19	Chemical fertilizer ²	10.50	348	4.07	510	718	2.30	11.36	....

¹ Acid phosphate, 80 lbs; muriate of potash, 80 lbs; nitrate of soda, 160 lbs.

² Acid phosphate, 80 lbs; muriate of potash, 10 lbs; tankage, (7-30) 100 lbs.

In computing the increase in this experiment hitherto the computation has been based on the assumption that the difference in yield between unmanured plots will be progressive. That is, that if the yield of plots 1 and 4 were 30 and 33 bushels, respectively, those of plots 2 and 3 would have been 31 and 32 bushels, had no manure been applied. In general this assumption has been justified in the other experiments of the Station, and so far as sections A and B of this experiment are concerned this is probably the more correct method of computation; but on Section C Plots 1 and 11, which, it will be observed, are continuous, have regularly given yields so much larger than those of the other unmanured plots of this section as to suggest the possibility that the land covered by these plots may have been at one time occupied by a fencerow, the tract lying near a barn, and for this reason it has been deemed best to calculate the increase on the general average of all the unfertilized plots.

By this method of calculation the average increase on Plots 2 and 3 combined is found to be practically the same as that on Plots 5 and 6 combined, but when the larger cost of the acid phosphate is deducted the net gain is a little greater on Plots 2 and 3.

These plots, it will be observed, are receiving about twice as much phosphorus as Plots 5 and 6, but at a lower cost.

The comparison of Plots 18 and 19 is very decidedly in favor of Plot 19, although the expenditure for fertilizer on that Plot is only about one-third that on Plot 18. Plot 19, however, while receiving a smaller total quantity of fertilizer and at a much smaller cost, yet receives more than twice as much phosphorus as Plot 18, and this phosphorus is all in an available form, thus illustrating the hunger of this soil for phosphorus.

LIME AND FLOATS TEST

This experiment was begun in 1905 in a 3-year rotation of corn, oats and clover, for the purpose of comparing the effect of different forms of lime and of obtaining further experience in the use of floats.

The land had been under the regular rotative cropping of the farm since its occupation by the Station, and for a considerable period before, and was in good condition. Twelve tons of manure per acre had been plowed under for corn in 1904. Three sections of 26 plots each are included in the test, the plots containing one-twentieth acre each.

For the crops of 1905 Section A (north end) was manured at the rate of 6 tons per acre only, because of the recent application above mentioned, limed and fertilized and planted in corn. Section B was sown to soybeans instead of clover, the beans to be followed by rye in the fall and corn in 1906. Section C (south end) was limed and fertilized without manure and sown to oats and clover. Thenceforth the manure, lime and fertilizers have all been applied to the corn crops, the manure being plowed under and the lime and fertilizers applied on the surface. The oats and clover receive no treatment.

The clover seeding failed in 1906, 1908 and 1909, and soybeans were sown instead and harvested as hay. As the soybean suffers less from lack of lime than clover the result has been a smaller apparent effect from the lime than might otherwise have been found.

The plan of treatment and average results of the work for the first five years are given in Table X, which includes the data for the clover and oats crops of 1910.

It is evidently too early to attempt to draw conclusions from this experiment. For a soil which is capable of producing a 5-year average of 64 bushels of corn, followed by 50 bushels of oats and 2½ tons of clover hay without any treatment the chief problem is that of maintaining this rate of yield.

So far as present results may be accepted as a guide they support other experiments of the Station in indicating that ground limestone and floats should be used only as reenforcements of manure or fertilizer and never as substitutes.

Ohio Agricultural Experiment Station.

CIRCULAR No. 105

WOOSTER, OHIO, SEPTEMBER 1, 1910

FLOATS

By E. W. GAITHER

The use of floats as a supplementary carrier of phosphorus, to be used in connection with farm manures and green manures, is becoming quite extensive in Ohio and the Experiment Station is constantly receiving inquiries as to the use of this material, in response to which demand we feel that we should furnish such information as we have on the subject in this circular, which will be followed by a bulletin on fertilizers and their use.

Floats is the commercial name for finely ground phosphate rock, which is a natural formation of what is technically known as tricalcium phosphate. This substance is but slightly soluble in water, but practice has shown that under the influence of decaying organic matter and bacterial action it is made sufficiently available to plants to make its use in connection with farm manures and green manures both profitable and desirable. It is not claimed that a pound of phosphorus in floats is as effective for immediate use as a pound of phosphorus in acid phosphate, but the cost of a pound of phosphorus in floats, as compared with the cost of a pound of phosphorus in acid phosphate, when both are used with manures, gives a net profit dollar for dollar about equal from the two materials, beside leaving a residual amount of phosphorus in the soil for future use largely in favor of floats.

The above results have been obtained on clay soils and silt loam soils, but we are not prepared to make an unqualified statement as to the use of floats on very light or sandy soils; however, where it is necessary to compost manure before applying to the soil, we feel sure that the use of floats on light soils with compost would be an economical success.

Practically all floats used in Ohio comes from the Mt. Pleasant district in Tennessee, and the greater part is made from low grade rock which cannot be used profitably for making acid phosphate, on account of the low percentage of phosphorus or the high percentage of iron and aluminum oxides present.

The brown rock phosphate, which contains less than 30 to 31 percent of phosphoric acid (P_2O_5) cannot be used profitably in making acid phosphate, especially when the haul has to be made any distance, so this grade of rock is ground and put on the market as floats. However, it does not necessarily follow that all floats is as high as 30 percent phosphoric acid, for by far the larger part of the refuse rock in the Mt. Pleasant district is below 28 percent phosphoric acid and we do not think it would be economical for the Ohio farmer to buy floats containing less than 24 percent phosphoric acid unless he can get it at a very low price.

The question has arisen, whether or not there is a difference between the availability of kiln dried and sun dried floats.

By chemical analysis we found that a sample of raw floats bought for use at the Experiment Station and subsequently ground to pass an 80-mesh seive, gave 26.77 percent total P_2O_5 , 6.54 percent of which was soluble in 2 percent citric acid. A sample of this was then heated until it was almost melted and again ground to pass an 80 mesh seive and analyzed, giving 28.17 percent total and 2.78 percent soluble in citric acid. This would seem to show that high heat would tend to decrease the availability of the P_2O_5 , so far as the chemical action goes, but this will have to be confirmed by plant experiments which are now in progress at this station, before we will be justified in condemning the use of kiln dried or calcined floats.

In order to give the farmer an idea of the difference between sun dried and kiln dried rock we will describe the methods in vogue in the Mt. Pleasant district. The kilns are made by piling wood and mixing the rock through it so that the wood will burn freely and then piling more rock on top, then the wood is burned.

Sun drying is done in large open fields where the rock is spread and dried by the sun, being cleaned by handling it with forks once or twice while drying. Kiln drying is seldom resorted to by the producers except during wet seasons, for the reason that it is cheaper to spread the rock on the ground and let the sun dry it than it is to kiln dry it, running the risk of the next rain wetting the rock again. In case the rock is kiln dried, only that which is close to the fire is heated red hot and this does not constitute more than one third of the pile.

Before floats came into use as a fertilizer it was the practice among the producers of phosphate rock, where kiln drying was resorted to, to burn their kiln and by use of forks to separate the fine rock and dirt from the salable rock and then burn another kiln on top of this refuse, thus accumulating a large pile of this low grade material which would necessarily be heated more intensely

than if the whole pile, including the marketable rock, were ground into floats.

Since the recognition of the fertilizer value of ground phosphate and the use of mechanical dryers has become general, these old kiln beds are being taken up and passed through the dryers, the larger pieces of rock of high grade are marketed for the purpose of acid phosphate making, and the finer pieces and other refuse are ground and sold as floats.

There may be some question as to this class of material being of as much value as the sun-dried product; however, there is not a great amount of this product available and we would judge that in a year or two it will all be used up and be entirely off the market.

There is what is known as the dryer system in use, which consists in passing the rock through hollow, revolving drums with holes of varying sizes, through which the small rock and dirt pass. The drum is heated by a fire below one end which passes up through and around the drum and dries the rock without heating it much over 212°F .

It will be readily understood from this that even though high heating does decrease the solubility of the phosphoric acid in 2 percent citric acid, an agent is not justified in telling a customer that kiln dried floats is worthless nor in making the statement that his firm is the only one which makes floats from sun dried rock.

The degree of fineness of floats is considered of great importance in determining its fertilizing value. We would advise that farmers insist upon a statement of the fineness of the floats they buy. Sieves running 40, 60, 80 and 100 meshes to the inch are commonly used in determining the fineness, and when ground for the purpose of making acid phosphate the practice is to require 96 percent of the total to pass an 80 mesh sieve. This fineness can be obtained upon a commercial scale and would not be too much for the users of floats to require, while a finer ground product of the same composition should be given the preference.

A fair requirement for floats would be, not less than 26 percent phosphoric acid, not more than 8 percent iron and aluminum oxides combined, and not less than 93 percent to pass an 80-mesh sieve.

This Station has been conducting experiments in the use of floats and acid phosphate for the reenforcement of manure since 1897. A report on this work is given in Bulletin 183, and later results in Circular 104.

Ohio Agricultural Experiment Station

CIRCULAR No. 106.

WOOSTER, OHIO, OCTOBER 1, 1910.

SEEDING LAWNS AND PERMANENT PASTURES.

The Station has successfully established several lawns by the following method: As soon as the ground is dry enough to work in the spring it is plowed and thoroughly pulverized by harrowing and cross-harrowing until in the condition of a garden. Unless the soil is very rich it should be made so, either by the liberal use of manure or of a complete fertilizer, the latter being preferable because of the seeds of weeds and coarse grasses usually carried in manure. For lawn purposes the fertilizer should carry 3 to 4 percent nitrogen, 8 to 10 or more percent phosphoric acid and 6 to 8 percent potash, and should be used at the rate of 600 to 800 pounds per acre, or 4 or 5 pounds to the square rod. An excellent lawn fertilizer may be made of steamed bonemeal and muriate of potash, used in the proportion of 200 pounds of the bonemeal to 40 pounds of the muriate. The two materials may be mixed together or spread separately, as is most convenient.

A mixture of equal weights of Kentucky Blue grass and Red Top, with a pound of white clover seed to a bushel of the mixture, is then sown broadcast, at the rate of two or more bushels per acre of the mixed seed, and harrowed in with a fine toothed harrow. If the ground should be very dry it may be rolled as part of the preparation for sowing, but the finishing touch should always be given with a smoothing harrow, or other fine-toothed harrow, as this leaves the surface in such condition as not to be so liable to be injuriously packed by rain as if finished with the roller.

The reason for mixing the Kentucky Blue Grass with Red Top is that the two grasses mature at different seasons, the Red Top reaching maturity some weeks later than the Blue Grass, thus keep-

ing up a better succession through the season, while the Blue Grass is better adapted to the dryer and the Red Top to the moister portions of the land. The clover is not only useful in thickening the sod, but by its ability to gather nitrogen it assists the growth of grasses with which it is sown.

For permanent pastures no better grasses have been found by the Station than the varieties above recommended for lawns. Sown together they give a succession throughout the season and adapt themselves to differences in soil, thus giving much better results than if either be sown alone. The seed of these grasses is relatively expensive, however, and it is more economical to reduce the quantity of seed of these varieties and substitute a moderate quantity of red and alsike clover and timothy seed. The first year after seeding the crop may be chiefly clover, and should be mown for hay. The second year it will be chiefly timothy, and after that the timothy will gradually disappear and the pasture grasses take its place. By this method of seeding not only will the first cost be reduced, but the clover will serve a most useful purpose in preparing the way for the grasses which are to follow. A mixture of 10 pounds Blue Grass, 8 pounds Red Top, 6 pounds Timothy, 4 pounds Red Clover and 2 pounds Alsike Clover per acre, will make a fair seeding. It will be well to divide it and sow one half crosswise of the other, harrowing the whole. In the case of pastures, as well as of lawns, the land should be manured or fertilized if not already rich, and here manure is the better material, if it can be obtained.

All old pastures or lawns should have an occasional dressing of manure or fertilizer. The object lessons in the scattered cattle droppings on the pastures demonstrate this point effectively. Such treatment will often thicken up the grass in an old lawn without reseeding, but if bare spots have made their appearance it will sometimes assist matters to apply a dressing of lime, at the rate of a bushel to the square rod, work it into the surface with a sharp rake or harrow, and after a few weeks re-seed as for a new lawn.

In those sections where the underlying rock is shale or sandstone it will often be found necessary to lime the land before Blue Grass can be grown successfully. For this purpose slaked or hydrated lime may be used at the rate of one ton per acre, or finely ground raw limestone in twice that quantity, the liming to be followed by fertilizing or manuring.

The Station's experiments have shown that it is often necessary to re-seed, as well as to use lime and manure or fertilizer, in order to bring an old pasture into profitable condition again.

Ohio Agricultural Experiment Station.

CIRCULAR No. 107

WOOSTER, OHIO, OCTOBER, 20, 1910

A SUCCESSFUL ALFALFA AND TRUCK FARM IN SOUTHEASTERN OHIO



SIR: I have the honor to transmit herewith and to recommend for publication as a circular by the Experiment Station, the accompanying manuscript entitled "A Successful Alfalfa and Truck Farm in Southeastern Ohio."

This paper, which has been prepared by Mr. W. A. Lloyd, Assistant in the Department of Cooperation, is based on a study of a farm in Hocking County, and develops the possibilities in connection with truck and fruit growing near a good local market and of growing alfalfa without great effort on the river bottoms in some sections of the state. It has been prepared in cooperation with the Office of Farm Management, Bureau of Plant Industry, United States Department of Agriculture, and was read and its publication concurred in by the Chief of that Office.

Respectfully,

L. H. GODDARD, *Chief of Department of Cooperation.*

Approved: CHAS. E. THORNE, *Director.*

A SUCCESSFUL ALFALFA AND TRUCK FARM IN SOUTHEASTERN OHIO

By W. A. LLOYD

A FOREWORD

The patient agricultural investigator often finds, after years of painstaking work with his pots and plots in the laboratory and field, that the application of the principle for which he has been searching has long been practiced by successful farmers. Indeed the object of much investigation is to ascertain the principles underlying successful practice. The Director of the Ohio Experiment Station has said to the farmers of Wayne County, "My greatest ambition is to do as good farming as is already being done by the farmers of this county and by such farming to discover facts that will be useful to them".

It is coming to be quite generally recognized that the best system of farming for any section is usually already practiced in that section. The entire scheme may not be found on any one farm; indeed, usually it is not. Very few men are successful along all lines of endeavor. A composite picture of the best practice on several successful farms in any section will usually illustrate pretty well the best farm practice for that section.

These successful farmers do not generally recognize that they have discovered anything; what they are doing is often the result of accident or force of necessity, or is the development of ideas handed down from previous generations. In their busy lives they know certain methods will produce certain results, but they have not had time to determine just why they do so. It also usually happens that their neighbors take them even less seriously than they take themselves. The men who "make good" on the farms are known among their fellows as "lucky" or "fortunate" individuals, and very little inquiry is made into the causes which have produced the results.

It thus happens that in no phase of scientific investigation can it so truly be said "There is nothing new under the sun" as in agricultural research. There has therefore arisen a system of scientific investigation known as the study of farm practice. This study consists in the investigation of those farms which are particularly successful along certain lines; in ascertaining why they are successful and how far the methods they are pursuing are applicable to other farms.

The following report is the result of such a study and is the first of a series of such investigations by the Ohio Experiment Station, in the course of which it is hoped to illustrate some solutions of farm problems which have been worked out by "the man on the job."

THE FARM DESCRIBED

The farm under discussion is located in Star Township, Hocking County, near the town of Haydenville, the seat of the National Fireproofing Co.'s factory, a concern employing about two hundred men. It is five miles from Nelsonville, a town of eleven thousand inhabitants and the center of an industrial community of probably sixteen to eighteen thousand people. It is seven miles from Logan, the county seat of Hocking county, with a population of six thousand. The farm is on a limestone pike connecting Logan and Nelsonville, and is in one of the greatest coalfields in Ohio. The supply of coal, with the present system of mining, is said to be sufficient for two hundred years.

Soil and Drainage. The farm contains 500 acres of land. It lies on both sides of the Hocking River and consists of 120 acres of river bottom land and 380 acres of hill land. Of the former about two-thirds is "first" bottom, subject to overflow. The soil of this is a very fine sand and silt loam underlaid with a coarser sand and, at the depth of two to three feet, by nearly pure sand. At a depth of about twelve feet a stratum of gravel is reached. The second bottom is a clay soil with some sand, which responds well to tile drainage. A complete system of drainage has not been installed, though the drains that have been laid are giving good results. An outlet for the drainage water is found in a well which is dug to the quicksand and walled with sewer tile. This well is capped over at a depth beneath that reached by the plow. A large part of the second bottom land along this river is apparently acid and very much in need of tile drainage. A system similar to or better than that in use on this farm could very probably be installed with profit on much of it.

The hill land is of the same general character as other non-glaciated soil of the section. It is made up of disintegrated sandstone, limestone, shale, fireclay, coal and iron ore of the coal measures, which have made a soil somewhat variable. The surface of the upland portion of the farm is quite broken. About half the area is covered with a second growth of timber and the remaining portion, amounting to nearly 200 acres, is in permanent pasture, except 40 acres which are in fruit.

Timber. The original timber consisted of white oak, poplar, hickory and other hard woods, and has nearly all been cut away. Some of the second growth is being utilized for bank props, for which a ready market is found at the nearby mines. The locusts thrive well, and much of the roughest portion of the upland might be profitably set to these and other trees.

Pastures. Much of the pasture land is underlaid with limestone and is therefore well adapted to the growth of blue grass. It has been given little care other than an annual removal of the sprouts which are so troublesome in pastures in many parts of Southeastern Ohio.

Live-stock. The permanent live-stock consists of four milch cows ten work horses and one brood sow. On the pasture from 150 to 250 sheep have been kept. From 15 to 20 hogs are fattened annually. A flock of 200 hens is kept.

Farm Crops. The bottom land, which is the only part of the land occupied by farm crops, is utilized this year as follows: alfalfa, 30 acres; corn, 25 acres; wheat, 20 acres; potatoes, 15 acres; melons, 7 acres; cabbage, cucumbers, onions, beets, etc., 8 acres; household and waste, 15 acres.



Fig. 1. An Alfalfa Meadow

METHODS AND ROTATIONS

Alfalfa. Alfalfa was introduced by accident sixteen years ago. Seed was purchased for mammoth clover, which was sown on wheat in April. About one-half of the seed proved to be alfalfa, which came up nicely in the wheat and was thought at the time to be sweet

clover. The plants came on well after the wheat was harvested, and upon investigation were found to be alfalfa. This led to the establishment of the five to six year rotation: corn, wheat, followed by alfalfa for three or four years. During all these years this method of seeding has been uniformly successful. The method of seeding in wheat is as follows: the alfalfa seed is sown during the first part of April each year, when the soil is dry, and is covered by using a spike-tooth harrow. It is desirable to get the seed into the soil before the usual "wet spell" that frequently comes the latter part of April. Wheat is not considered a profitable crop, and with the development of the alfalfa propaganda in Ohio all the "difficult ways" of succeeding with this crop have been tried, but none have been found as good on this farm as that discovered by accident.

About the middle of August the wheat stubble is clipped and a good crop of alfalfa hay is cut about the first of the following October. No advantage has been found from allowing this growth to remain on the ground through the winter. The alfalfa is grown exclusively on the first bottom, on which water frequently stands for several days at a time, particularly during the winter and spring. This does not appear to be injurious to the crop, nor does the sand and sediment left in the wake of the flood. The plants are successful in finding their way through a deposit of from two to three inches and show increased vigor from the effect of the overflow.

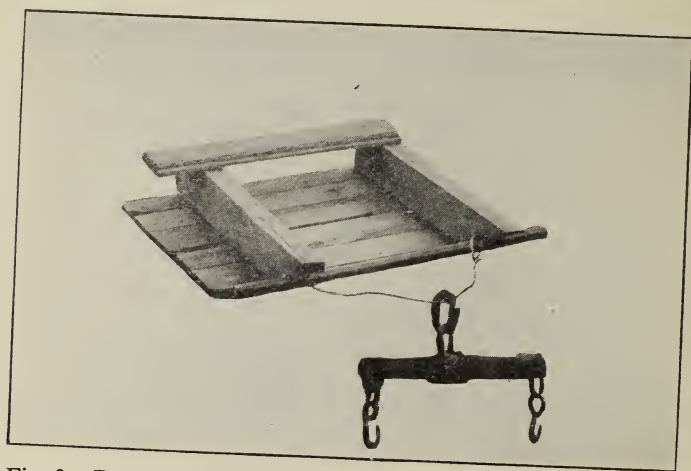


Fig. 2. Drag used for covering alfalfa sown in the standing corn.

Last year a small field was seeded to alfalfa in the standing corn with good results, and this year about 20 acres have been seeded in the same way. The seed is sown after the last cultivation, and

covered with a small plank drag. This is a rather novel, homemade implement, 34 inches wide and 22 inches long, that works between the rows of corn. (See Fig. 2.)

This dragging covers the alfalfa nicely and leaves the ground in a fine, level condition. The same method of seeding is followed on the lands of the New York Coal Co., at Nelsonville, where 50 acres of alfalfa were successfully seeded in this way last year. Should this method continue to be successful it will take the place of the present practice of seeding in the wheat. That both of the above methods, in fact that many different methods of seeding are being successfully followed by alfalfa growers in Ohio, and that no one method can be said to be the correct one for all conditions, is developed by an investigation being conducted by this Department, the report of which will be published in a forthcoming circular.



Fig. 3. This alfalfa field was seeded in the wheat in the spring of 1909. Second cutting, 1910, ready July 18th.

The method of harvesting the alfalfa is also somewhat different from that ordinarily pursued. The alfalfa is cut in the morning as soon as it is dry from the dew, tedded and allowed to lie in the swath during the first day. The second day it is raked up and drawn directly from the windrow to the barn or the market. In this way excellent hay is made. Except in case of threatened rain, no alfalfa is ever put into the shock. It is cut three times each season, the total yield being from four to six tons per acre. The alfalfa is usually allowed to stand three to four years, after which the land is plowed for corn.

Corn. This is a very important crop on this farm; scarcely less so than the alfalfa. The variety grown is a cross-bred corn originated by the grower by crossing Leaming with a local variety. It possesses the Leaming type to a considerable extent, is early maturing, a vigorous grower and seems well adapted to his conditions. The seed is drilled in rows three feet four inches apart and fifteen inches apart in the row. The cultivation is frequent and shallow. The crop is cut by hand and husked with the shredder. The yield is from 75 to 90 bushels per acre. Yields in excess of the latter figure have been secured as a 20-acre average. The corn this year gives promise of making good.



Fig. 4 The second cutting of alfalfa ready for the knife, July 18th.

An interesting observation in connection with this year's crop is the influence of environment and the adaptability of the corn to the condition in which it finds itself. At the time of planting, through a mistake, the wrong plate was used in the planter and the corn was distributed only about 10 inches apart in the row on part of the field before the mistake was discovered. No thinning was done. In the part of the field planted regularly a very large number of stalks set two good ears; indeed, by actual count in different parts of the field more than a half of the stalks had two, and in some cases three ears. On the more thickly planted portion of the field very rarely was more than one ear found on a stalk.

Wheat. This crop has yielded only about 15 bushels per acre and is not considered profitable. It has only been retained in the rotation as a means of securing alfalfa.

THE MARKET GARDEN

On that part of the farm devoted to potatoes, melons, cabbages, etc., no particular rotation system is used; although, except in the case of potatoes, the same crop is rarely raised on the same land more than two years in succession.

Potatoes. This crop produces a larger amount of gross income than is secured from any other one crop on the farm. It is grown exclusively on the second bottom. Repeated failure has followed attempts to grow it on the first bottom. Early varieties are planted, as the late varieties have proven unprofitable. Potatoes have been raised for the last 15 years on the same field. Crimson clover and rye are sown after the potatoes have been harvested. The rye is manured during the winter, using from 10 to 12 tons per acre, and is turned under in the spring after it has made a good growth. The potatoes are put in the ground with a planter and about 500 pounds per acre of high grade steamed bone is used in the row. The tubers are harvested with a digger. Alternate rows are dug and the vines thrown on the intervening undug rows, and the rows thus vacated are planted to late cucumbers. The digger leaves the ground in good condition for the cucumbers. The only further attention needed is the running of a small one-horse roller over the rows. This roller is a handy contrivance made from a sewer tile. (See Fig. 5.) In digging the remaining rows the hitch to the digger is so arranged that very few cucumber vines are injured from trampling by the horses.

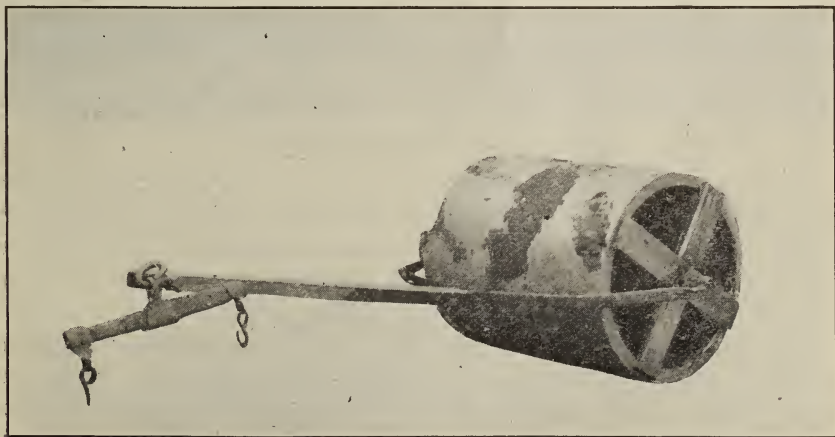


Fig. 5. A handy one-horse roller.

There is an almost unlimited local demand for pickles and the net profits from the secondary crop are sometimes in excess of that derived from the first.

The Melon Crop. This crop has been a very profitable one in the past. For three years it has been damaged by an attack of a small larva which burrows in the root and causes the plant to die. A 7-acre field was almost completely ruined in this way this year. Experience in former years with this larva, which it is suspected may be that of the striped cucumber bug, has caused to be taken out what is termed "mutual insurance"; i. e. after the melons are planted, two rows of late cabbage are planted between each two rows of melons. These are to be removed if the melons escape destruction. (See Fig. 8.) This has proven particularly cheap insurance this year, as nearly the entire crop of melons has been destroyed and the late cabbage looks very fine.



Fig. 6. Beets and Muskmelons.

The practice of raising two, and in some cases, three crops on the same land each year is a distinguishing feature in the management of this farm. In this way the area devoted to the garden crops is more than doubled. It is practiced with the beets, onions, late beans, early sweet corn, melons and turnips. (See Fig. 6.)

Sweet Corn. This crop is another important source of income on this farm. Successive plantings are grown, beginning with Premo for the very early and finishing with Country Gentleman for the latest. Plantings are so timed as to give a constant supply of green corn from July until frost.

DISPOSITION OF CROPS.

So far as possible all crops are marketed direct from the field. Alfalfa hay is sold at Logan and Nelsonville at \$12 per ton delivered loose from the field. The shrinkage on alfalfa hay between harvest and January under ordinary storage conditions has been ascertained to be about 20 percent. Corn was sold last year at 70 cents per bushel and potatoes at 85 cents. Of this latter crop the supply was sold so closely that seed had to be purchased this spring. No loss was entailed by this operation, however, as the necessary seed was purchased at 25 cents per bushel. During the truck season wagons run every day with beets, onions, sweet corn, beans, cucumbers, and other garden stuff to supply the wants of the mining and factory people.



Fig. 7. Cabbage and muskmelons

The greater part of the produce of the farm is sold at wholesale to dealers. This method is preferred, but when the local Merchant's Association sets a buying price that is lower than the market justifies, wagons are immediately put on the street and a prompt adjustment of the price usually follows. It is not at all unusual to see four or five wagons loaded with the produce of this farm on the streets of the market town at one time. The reputation of the quality of the products of the farm is such that much of it is engaged in advance; indeed, often before it is planted.

MANURES AND FERTILIZERS

Manure is bought and shipped from the mines and from Nelsonville. Usually about ten cars or from three to four hundred tons are secured in this way annually. This manure costs \$2 per carload at the mines; the freight rate is 40 cents per ton and the total cost of the manure including labor is 75 cents per ton spread on the field.

Hands are sent from the farm to load the cars and it is taken direct from the car to the field. The manure is used on rye for potatoes and on the truck land. Manure is also hauled from Nelsonville during the summer. Each team can draw two 2-ton loads per day. This manure is put in a large heap and forked over several times and thus made into a compost for use with the melons. In addition to the manure, about 10 tons of high grade steamed bone is used, which costs \$27 per ton in car lots. This is used on the wheat at the rate of 200 pounds per acre and also on the potato and garden land.



Fig. 8 Cabbage planted in the melon field as insurance against loss of the latter crop

FEEDING AND CARE OF LIVE-STOCK

The live-stock operations on this farm are very small and are destined in the future to be even smaller. Considering the cheap source of manure and the ready and handy markets it is considered there is no class of live-stock to which the corn and alfalfa hay could be fed with profit. The live-stock kept on the farm is very largely of a permanent nature. Four cows are kept to furnish an abundance of milk and butter for the family. Two of these are fresh in the spring and two in the fall. They are fed alfalfa hay and short

corn. Two litters of pigs are raised, one spring and one fall. All are slaughtered on the farm and used by the household or sold as dressed meat to families living on the farm.

Horses. Some colts are raised; these are to supply the needs of the farm in taking the places of worn out and diseased animals. In the past twenty years very few horses have been sold. The loss of horses has been quite large. In one year animals were lost to the value of \$800 from what was thought to be eating ensilage. To test this belief the next year the same feed was tried on a mule and it died. Since this time no ensilage has been fed to horses. During the winter when horses are not doing heavy work one feed of alfalfa hay and one of shredded fodder is given each day. During the latter part of the winter a small amount of molasses is added to the shredded fodder. This adds to the palatability of the ration and also to its feeding value. Corn and alfalfa hay are fed during the summer,

Sheep. Sheep have been really the only livestock proposition on the farm and they will be discontinued. The hill land is naturally adapted to sheep, but the devastation wrought by dogs makes it impracticable to keep them. A few years ago a solution of the dog nuisance was evolved which worked very satisfactorily for a time. The cooperation of a few neighbors was secured, in all controlling several thousand acres of land. One of the farmers then went to the leaders of the hunters and talked to them after the following fashion: "You want to hunt. We don't want you to. Now, it does not seem right to deprive you of your sport altogether. If you will keep your dogs off our lands during the time our sheep are in the pasture you can hunt the rest of the year." This plan was agreed to and the pact was kept for a number of years and worked very satisfactorily. It fell into disuse as much from the non-insistance on the part of the land owners as from any other cause. The plan has many things to commend it. It gives to the hunters a semblance of what they believe to be their rights, puts them on their honor and promotes their good will rather than their enmity. It is certainly worthy of further trial.

Poultry. The poultry is a source of considerable income during the winter months, when it is given good care; but with the coming of summer everybody gets busy with other work and the chickens are left to scratch for themselves. From November until May the hens are fed a morning ration of wheat in the litter; a mash of small potatoes mixed with enough alfalfa leaves gathered from the barn floor to make it stiff, for a noon feed, and shelled corn in the litter at night. Beef scrap is kept before them at all times, and green food furnished by cabbage, sugar beets and other vegetables saved from the garden.

THE ORCHARD

Eight years ago forty acres of hill land were set to an apple orchard; Rome Beauty, Grimes' Golden and Stayman Wine Sap being the varieties chosen. Peach trees were used as fillers between the apple trees. The peach trees have borne profitable crops and have a very satisfactory crop this year. All the trees are set in the sod and are dug about each year. They have not been fertilized or mulched. The trees have made a good growth. They are pruned, sprayed and well cared for. As soon as the apple crop becomes profitable a cold storage building will be erected in which to handle it. A small plum orchard has also been planted from which a satisfactory crop is being harvested this year.



Fig. 9. A part of the orchard showing the rocky condition of the upland.

THE FARM LABOR

The management of the labor proposition on this farm is worthy of particular consideration. The hands employed regularly reside on the farm. They are paid a cash wage of \$1.20 for ten hours work. In addition to this each head of a family is furnished a house, rent free, with a garden and the use of a horse to plow and tend it. A part of the labor is furnished by boys, children of the families living on the farm. During the busy season some extra help is employed. In the winter the manure is procured and spread on the fields and a number of bank props are cut and marketed. When work is slack some of the men are permitted to work in the factory or mines for short periods, returning to the farm again when there is need for them. During the time they are working away from the farm they pay \$3.00 per month house rent.

The operator of this farm is a splendid manager of labor, very considerate of his men, and has so systematized the work that each man does Sunday chores only at long intervals. In deciding on any detail of farm work the workman who is to have it in charge is consulted, his ideas secured, and he is led to suggest the method he himself wishes to pursue. If satisfactory this is adopted as the laborer's idea and both the diligence and pride of the man in the successful execution of his task are assured. It is largely owing to this happy faculty that it has been possible to keep a good corps of steady, efficient men on a farm that is situated in the heart of one of the great industrial centers of Ohio.

FARM EQUIPMENT.



THE machinery for the operation of the farm consists of a very complete outfit, well adapted to the operations involved. There may be enumerated a traction engine, husker, shredder, self-binder, mowing machines, side-delivery rake, potato planter, potato digger, grader, power sprayer, plows, cultivators, etc., on which the owner places a total valuation of \$3,500.

RECAPITULATION.

LAND INVESTMENT

120 acres (including improvements) which is valued	
at \$100 per acre, total value	\$12,000
380 acres (including improvements) which is valued	
at \$25 per acre, total value.....	9,500
Total.....	\$21,500.00

For this the tenant pays a cash rent of \$1,200, or nearly 6 per cent. If we deduct the value of the hill land, from which he gets very little return, he is paying \$10 per acre for the remaining producing part of the farm, or 10 percent on the investment. Figuring 4 percent as a fair return for the money, this would represent a land value of \$250 per acre.

It should be said here that this farm is an estate and that the tenant is one of the heirs. The estate is so disposed of by the testator that it cannot be sold during the life of the surviving wife, the mother of the tenant. It is stipulated in the lease that the landlord shall furnish the alfalfa seed used on the farm.

The following items of gross receipts and expense are taken from the day book of the farm for the year 1909.

GROSS RECEIPTS

Alfalfa hay	\$1,295	
Corn, 700 bushels at 70 cents per bushel.....	490	
Wheat, 100 bushels at \$1.00 per bushel	100	
Total farm crops.....		\$1,885
Potatoes, 3,000 bushels at 85 cents per bushel.....	\$2,550	
Melons.....	297	
Cabbage.....	150	
Sugar corn.....	500	
Other small stuff.....	400	
Total garden.....		\$3,897
Sheep (wool only)	\$175	
Hogs	300	
Chickens (eggs).....	150	
Total live-stock and poultry.....		\$ 625
Bank props.....	\$275	
Outside labor (husking and shredding).....	\$150	
Total miscellaneous.....		\$ 425
Total gross income.....		<u>\$6,832</u>

EXPENSE

Rent.....	\$1,200	
Interest on investment—		
Live-stock (owner's valuation)	\$2,260	
Equipment (owner's valuation)	3,500	
Total ..	\$5,760 at 5%	278
Labor.....	1,084	
Manure.....	225	
Commercial fertilizers.....	270	
Five percent depreciation on machinery.....	175	
Repairs on machinery (1909).....	160	
Taxes.....	40	
Seeds.....	70	
Insurance.....	5	
Total expense.....		<u>\$3,457</u>
Net returns from the farm.....		<u>\$3,375</u>

No household account is kept, so that the surplus over the cost of living is not obtainable. The tenant considers his time worth \$8 per day. This would amount to a salary of \$2500 per year, and would still leave him a comfortable balance of \$875 for a sinking fund.

The family lives well. It is a home of books and music, of education and refinement. Each of the family of seven children either has received or is receiving a high school education. To give them this advantage it has been necessary to send them away from home. The expense has been considerable and all years have not been as prosperous as 1909.

CONCLUSIONS.

The splendid success achieved on this farm is, as is nearly always the case, largely attributable to the personality of the man. It is the fruit of a dogged determination to win, and of industry intelligently applied. To use his own words, "I had to succeed." The farm is no better than others along the river, some of which are even more advantageously located than this one. But he saw the need of the industrial community at his door and set about to supply it. He has made the best use of his land. He has worked along the lines of least resistance. He produces the crop that gives the largest net returns for the labor. He grows what the other fellow doesn't. He studies the market. When a demand arises he has something to supply it. He possesses the rare combination of being a good producer and a good seller done up in the same package. He is a good manager of men. He is willing to live and let live. If we were to measure his success on a percentage basis we would make it:

Individuality.....	75 percent
Advantageous location of farm.....	15 percent
Land.....	10 percent

The justice of the small percent given to the land in this particular case is apparent from the following: When he took charge of the farm, 22 years ago, the gross returns from it were less than the amount he now pays for rent. The soil upon which he now produces his crops of 175 bushels of potatoes per acre, his melons and garden vegetables, produced only 8 bushels of rye per acre. This land he brought up to its present high state of fertility by the use of cowpeas and manure. Now he no longer needs the cowpeas. In four years by this method he increased the yield of rye from 8 to 22 bushels per acre.

Yet the advantageous location of the farm has had much to do with the success that has been won. It should by no means be considered that such results are obtainable on a farm situated remote from markets, which would necessitate expensive shipping and marketing. However, there are opportunities near every large manufacturing plant for a few such farms as this. The important thing is, this man saw the opportunity and took advantage

of it. There are other farms in this valley even more advantageously located than this one, with more bottom land and nearer the same markets, that are being managed as corn and timothy hay propositions whose owners say they are barely breaking even.

The cheap and handy manure supply has made the elimination of live-stock possible. The 380 acres of hill land he feels to be an incumbrance. He would gladly be rid of it. Aside from the 40 acres set in fruit it will be largely abandoned. He sees good money in it as a forestry proposition; the locust thrives well on it, but he feels that he has his hands full. He is working up to the limit, and does not wish to take on more care.



Fig. 10. Plant of the National Fire Proofing Company. An important factor in the success achieved on this farm.

His method of alfalfa growing is probably only adaptable to those similarly situated. Sweet clover, which grows everywhere in this valley, has thoroughly inoculated the soil and the annual deposit of sediment brought down from a limestone area has taken care of the lime requirements. The first bottom lands of this river seem to be naturally adapted to the growth of this crop. Methods which have succeeded here would probably succeed on other farms where similar conditions prevail. Alfalfa has not found a very wide adaptation in southeastern Ohio. Its principal home seems to be in the

bottom land along the Muskingum, the Ohio, the Scioto and the Hocking Rivers and their tributaries. To farmers in these valleys and to others similarly situated his methods are of interest and worthy of experimental trial.*

*The name of the man operating this farm is withheld at his request, as he wishes to avoid the correspondence which the publicity of this circular would probably bring him. His farm has been visited on different occasions by a representative of the Experiment Station, his growing crops inspected and his books examined. The manuscript of this circular was gone over carefully with him before publication and has received his approval.

Ohio Agricultural Experiment Station.

CIRCULAR No. 108

WOOSTER, OHIO, JANUARY 25, 1911.

ORCHARD PRACTICE

By W. J. GREEN.

STARTING AN APPLE ORCHARD.

Soil suitable for an apple orchard is not hard to find if one avoids that which is too wet for farm crops and is not susceptible of good artificial drainage. Soil upon which elm, black ash, scarlet maple and pin oak trees thrive is not suitable.

Orchard soil indicated by trees and crops. Sugar maple and chestnut trees usually indicate apple tree land and soil where wheat, oats and potatoes thrive is usually suitable for an apple orchard. The soil may range from that having a large percentage of sand and gravel in it, to a moderately heavy clay, and should be fertile enough to grow fairly good farm crops.

Site and slope. The site may be a hill or a level plain, but the former is less liable to be visited by frosts than the latter.

A north slope may well be chosen for such winter sorts as drop early, because of premature ripening, and the opposite side of the hill affords the right condition for the high coloring of varieties which are tardy in maturing. The eastern side of a hill is usually more fertile than the western, hence is to be chosen for those varieties which need plenty of food to bring the fruit to a marketable size.

Choice of cultural methods. In case an orchard is to be tilled the soil requires about the same preparation for the trees as should be given for farm crops.

It is well to settle, at the outset, whether the orchard is to be cultivated or kept in grass and mulched. The choice is to be determined largely by local conditions. On hillsides, where washing is likely to occur, tillage may be impracticable. In such cases the only way to prevent serious erosion is by keeping the orchard in grass and to use straw, corn stalks, or some other material about the trees as a mulch. The problem presents greater difficulties when the soil will not support an ample growth of grass. This necessitates the use of manure or chemical fertilizers, along with the straw or other material, to promote the growth of grass. Lime may be very helpful on sour soils to promote the growth of white clover and Kentucky blue grass. On level land either method may be followed successfully and, in any case, more depends upon the man than upon the plan adopted.

Advantages of the mulch system. The chief advantages of the mulch system are that the trees begin bearing at an earlier age, the fruit is more highly colored, and there is less erosion than under cultivation.

Advantages of cultivation. The advantages in favor of cultivation over grass and mulch are, reduction of the cost of growing the orchard, because of the income from the crops which may be grown, and the elimination of the dangers of fire and mice.

How to use mulch. If an apple orchard is to be grown in grass, a mulch of coarse manure or some material which will hold moisture, should be placed on the ground around the trees as soon as planted. At first the circle of mulch need not be more than three feet across, but more material is to be added each year and the mulched area should extend a little beyond the spread of the branches. The grass between the rows of trees should be cut once or twice each season and placed about the trees or left to decay where it falls. The bringing in of material for mulching will be necessary sooner or later, but additions of this sort increase the supply of humus, which means more plant food and a more uniform water content of the soil.

Cover crops, uses of. In case of cultivated orchards, crops may be grown and removed for a limited period, but to avoid depleting the supply of humus it is necessary to plow under clover, soy beans, cow peas, rye, vetch or other plants. The growth of cover crops should begin at an early period of the orchard's existence. If delayed too long and other crops are grown and removed exhaustion of humus will result and it will become impossible to secure a satisfactory growth of plants to plow under, because of the shade of the trees.

Soy beans may be sown in rows in May or June, so as to admit of cultivation, following with a crop of rye to be plowed under in the spring. This course may be varied to suit the conditions and needs of the trees.

Wrong methods. Clean cultivation of orchards, without the use of cover crops, and to allow trees to stand in grass without mulching are equally bad practices.

Time of planting. Apple trees may be planted either in the fall or spring, but on sandy or gravelly soil the former season is to be preferred. Fall planted trees should have a small mound of earth thrown about them, but no mulch is to be applied until the following spring.

Low heads desirable. The formation of suitable tops is most easily secured by using one-year-old trees, but two-, or even three-year-old trees, may be properly shaped by cutting off all side

branches and starting a new head at the proper height. Low headed trees are more satisfactory than those with high tops. Two feet is about the right height from the ground to start heads, and the branches should rise, on the line of a spiral, as buds are placed on the twigs.

The reduction of both tops and roots by severe pruning does much to insure success in planting and makes possible the formation of a well balanced head at the start.

Reliable nurseries. What nurseries are reliable and sell trees which are true to name are questions to which absolute and definite answers cannot be given. Most nurserymen make some mistakes, but the blame for the most serious blunders and misrepresentations must be placed upon irresponsible dealers. It is as easy to learn the reputation of nurserymen as of other business men.

Latitude where trees are grown. It makes little difference whether the trees are grown in one section of the country or another, provided they are equally thrifty and healthy. There is no good reason for sending north, or to any other point of the compass for trees, simply for the purpose of securing stock from another latitude than where the trees are to be planted, nor is there anything to be gained in passing by the small home nursery in order to choose from an alluring list of high priced novelties.

Space between trees. The space to give apple trees in an orchard varies according to the soil and variety. On good soil the strong growing sorts require about forty feet in each direction, at maturity. The spaces between may be occupied for the first ten or twenty years with "fillers."

Apple trees the best fillers in an apple orchard. The best fillers in an apple orchard are apple trees which are upright in habit of growth and begin to bear at an early age. Those of a spreading habit may be used if precocious. The first class is exemplified by the Yellow Transparent and Wagener, which may be planted in the rows, both ways, between the permanent trees. Oldenburg (Duchess) and Wealthy may be used, with some caution, in the same manner. Jonathan, Ben Davis and Gano are suitable to plant in the centers of the squares between the permanent trees.

Safe rule for using fillers. Peach, and other vigorous growing trees, are unsuited to be used as fillers in an apple orchard, unless confined to the centers of the squares. They ought never to be planted in the rows with the apple trees. The only safe rule in the use of fillers is that nothing shall be employed for the purpose which is more vigorous in growth than the permanent trees, and that the removal of fillers shall be begun as soon as there is evidence of crowding.

There are various methods of arranging trees in the orchard, such as the square, triangular and quincunx, but the square plan has the most advantages because of simplicity.

Planting the trees. When the trees are planted on well prepared ground there is no need of digging holes much larger than sufficient to receive the roots. It is well to plant the trees an inch or two deeper than they stood in the nursery and to lean them slightly toward the southwest.

Planting in sod entails more labor, as the holes should be two or three feet across. It is a good plan to dig the holes in the fall or during the winter, throwing the soil in compact conical heaps, so that it will be in good condition for early planting.

Varieties for southern Ohio. The selection of varieties is a perennial problem. In the southern part of the state the Rome Beauty stands at the head of the list for market. Grimes and Jonathan are favorites for early winter market. Ben Davis, Black Ben Davis and Gano are profitable varieties. York Imperial is satisfactory except that it scalds in storage. Delicious and Stayman are rated as very promising.

Varieties for northern Ohio. In the northern part of the state the Baldwin is the leading variety. Grimes and Jonathan are also favorites. In limited areas the Northern Spy is profitable. Sutton Beauty has not been generally planted but is satisfactory wherever tried. R. I. Greening is an old favorite. Rome Beauty, Ben Davis, Gano, York Imperial, and Stark do not color well except on warm soils and in favorable seasons, but each has its admirers. Delicious and Staymen promise well, but the latter is rather dull in color.

The list of summer and fall varieties is essentially the same for all parts of the state. The most commonly grown are: Yellow Transparent, Oldenburg, Red Astrachan, Chenango Strawberry, Maiden Blush, Wealthy, Jefferies, Fall Pippin and Rambo.

TRAINING AND PRUNING

Training young trees. Training the young orchard is more needful than pruning, and should consist mostly in shaping the trees or keeping them in form and properly balanced. Very often the side opposite the direction from which the prevailing winds come becomes heavier than the side towards the wind, and the removal of some of the branches and heading in of others becomes necessary.

Some shoots become too rampant and need checking to preserve the balance of the tree, and others can be bent and tied to fill the open spaces. Work of this kind and the removal of water sprouts may be done in the summer.

A bushy, or clustered habit of growth, is not uncommon even in the case of young trees, and needs to be corrected by the removal of surplus branches.

Pruning old trees. Dead and half dead branches are to be removed from old trees. Canker infected limbs are to be cut off or treated. If branches cross, one is to be removed, but there is still greater need of surgical work where a branch overlaps one or more below, causing a matting of foliage. When branches cluster in this manner the fruit seldom colors properly nor does it reach full size and is deficient in flavor.

In an old orchard too closely planted, the tops of the trees may need to be removed in order to facilitate spraying and picking. The ascending branch should be cut off just above a lateral, and if possible, the latter should be on the south side. Large wounds should be covered with some material to exclude the air.

Excessive pruning is quite possible and it is well to avoid letting in too much sunlight upon the bare bark of the branches. Sometimes two or more years should be taken to complete the work in case of old trees. Pruning is best done late in winter or early in the spring.

Objects of pruning. Definite and inflexible rules for pruning cannot be given, but one can easily learn to adapt different operations to special cases, by keeping in mind that the objects sought are to shape and balance the tree in its early stages; later to open up the center to sunlight, and in old age, where there has been neglect, to prevent decay as well as to remedy errors. In rejuvenating an old orchard pruning is the first thing to be done.

Scraping the old bark from the body of the trees is thought by some to be the next important operation, but if spraying is thoroughly done there is little need of scraping. The bodies and large limbs may be washed with a solution of 3 or 4 pounds of concentrated lye in a barrel of water with better results than scraping.

SPRAYING

The Spray Calendar (Bulletin 199) outlines the plan of operations for the control of insects and diseases.

Spray mixtures. It is well, in all cases, to plan for warfare against the San Jose Scale. Its presence does not require much extra effort, as the same materials, viz, lime and sulfur, are used against both the apple scab and scale. The addition of arsenate of lead makes a compound which is efficient against the above and the

apple worm, canker worm and sooty fungus. Bordeaux mixture and Bordeaux and iron sticker, with an arsenical compound, are likewise efficient. The injury done to apples by Bordeaux in the unfavorable season of 1910 has created a strong sentiment against it in favor of lime and sulfur. It is probable that Bordeaux, because of its cheapness and simplicity, will still be used in the home orchard, but commercial growers, quite generally, seem to favor the lime and sulfur compound.

General effects of spraying. So far as efficiency against disease is concerned it matters but little whether Bordeaux or lime-sulfur is used, but the former causes russetting of fruit and sometimes injures the foliage. Thorough and judicious spraying does more than to protect the fruit against insects and diseases. It preserves the foliage, thus promoting the health of the tree; increases the size of the fruit and heightens its color.

Well sprayed trees have increased power to withstand untoward influences of all kinds.

Manner of spraying. The manner of spraying is important. Good work cannot be done with a pressure of much less than 100 pounds. This is easily secured with a power sprayer and with some difficulty if the best makes of hand pumps are used.

THINNING

Thinning apples. The necessity of thinning apples is far greater than is commonly known. The time to do this work would be when the apples are about the size of marbles, if it were not for the fact that one of the objects of thinning is to remove defective fruit. All apples showing stings of any kind, hail marks, spots of scab, spray or frost injury, or any other deformity should be removed even though the crop may be light. Evidently this cannot be done properly until the fruit is nearly half grown. The overloaded trees may be thinned first, however, taking care to look for fruits which have any sort of deformity. How much good fruit to take off no one can say, but it should always be a little more than seems necessary. The past season the removal of half the fruit from heavily loaded trees was not sufficient. When a tree with a spread of branches of 25 or 30 feet gives promise of a crop of more than 20 bushels, thinning is needed to keep within that limit. Some trees may easily hold a crop of more than 20 bushels, but rarely is this the case if none but first class fruit is desired. When we have followed the rule to allow the apples to remain as near together as 6 to 8 inches, too many have been left. Nothing short of observation and practice will enable anyone to thin apples properly, and the error is nearly always on the side of leaving too many.

The coloring of apples. The coloring of apples is influenced greatly by thinning. It is well known that when two pickings are made that half colored fruits left at the first picking will, within two or three weeks, increase in size and put on more color, rivaling the specimens first removed. Earlier thinning accomplishes this result in a still more marked manner.

There is also a greater number of windfalls from unthinned than from a thinned tree, partly due to decrease of defective fruits by thinning, also to lessened drain upon the vitality of the tree.

Owing to the necessity of producing a better grade of fruit than formerly, and of more careful packing, thinning the fruit cannot be neglected.

Thinning is one of the measures to be taken to induce annual crops, but alone it cannot produce the desired result, nor can varieties in which the habit of fruiting in alternate years is strongly fixed be much changed in this way.

ORCHARD REJUVENATION

Rejuvenation of an old orchard. In the rejuvenation of an old orchard it may, or may not, be necessary to use commercial fertilizers and to cultivate the ground.

If crops were grown in the orchard during its early years, until there is but little humus left, it is not likely that fertilizers which do not supply vegetable fibre will have much effect, nor will cultivation prove effective in all cases. On soil where the roots are near the surface plowing may do harm. If it is evident that there is a lack of humus this must be supplied by top dressing with manure, to which may be added a good grade of commercial fertilizer, of at least double the quantity used on farm crops. Or if the trees are not too large it may be possible to grow some cover crop, using fertilizers also.

Fertilizers. If the trees lack vigor 50 to 100 pounds of nitrate of soda per acre applied as the buds are opening will prove useful. In the fall or spring use 100 pounds of sulphate of potash and 200 pounds of bone meal per acre. These quantities are tentative, as the exact amounts needed cannot be foretold.

It is well to stimulate the growth of grass with nitrate of soda in an uncultivated orchard, thereby increasing the supply of humus. If the sod is broken up and the ground cultivated and leguminous crops grown, less nitrate of soda is required. Poorly colored fruit and heavy foliage indicate that there is a sufficient supply of nitrogen.

It is well to remember, however, that light colored fruit does not always show that there is too much nitrogen. It may do so if there is a vigorous growth, but poor coloration may result when the foliage is greatly weakened by disease, or when too much fruit is left on the tree to mature properly, or when the water supply is limited.

The use of straw in connection with fertilizers on old orchards. In most cases it is safer to use plenty of straw, in connection with fertilizers, on an old orchard than to plow and attempt to grow cover crops. The exceptions to this rule occur mostly in case straw cannot be procured, and where the trees do not shade the ground to such an extent that cover crops cannot be grown.

How to approach the problem of orchard rejuvenation. The only way to approach the problems relating to orchard rejuvenation is to study all the conditions and then institute such practices as seem to be advisable. There may be good reason to modify the method as the work progresses, as new facts come to light, but this cannot be considered as a weakness on the part of the owner nor those whose advice he has sought.

A beginner is apt to make the mistake of undertaking to remodel an orchard which is too far gone to be rejuvenated, and to lay too much stress upon the importance of a single phase of the work. The correspondence which comes to the Station indicates that many believe that vigor may be imparted to a tree by severe pruning, while others think that spraying is a panacea for all tree evils.

Because of narrow views, and inability to couple cause and effect, many will fail in the work of orchard rejuvenation, but the attempt is worth while for we have many thousands of acres of idle orchards within the state. Ohio has about half as many apple trees as a generation ago and the product has fallen to less than one-fourth.

There are yet enough idle trees left, in good condition, to increase the average annual product by one million bushels. One county alone, last season, by rejuvenating 117 orchards, increased its product one-eighteenth part of one million bushels.

Many of these orchards would pay back in one year the cost of putting them in shape and several hundred percent on value of land besides. In several cases a net profit of \$400 per acre has been secured from an abandoned orchard. It is like reaping where one did not sow to bring one of these orchards into its own again. An investment in one of these orchards is better than gold mine stock for there is no "luck" about it. If there is any risk about operations of this sort it is because of lack of judgement and industry. To take a neglected orchard and bring it back to usefulness does not require much capital, except in brain and muscle, but it is an achievement worth while.

Ohio Agricultural Experiment Station

CIRCULAR No. 109

WOOSTER, OHIO, FEBRUARY 1, 1911

ORCHARD SPRAYING SUGGESTIONS FOR 1911.

ADVICE SUPPLEMENTAL TO SPRAY CALENDAR (BULLETIN 199)

By W. J. GREEN, A. D. SELBY, H. A. GOSSARD

In orchard spraying for 1911 inquiries are received as to what fungicides to use to control apple scab and other diseases, and what insecticides to combine with them or to use separately for codling moth, curculio, etc.

I. SPRAYING TO PREVENT APPLE SCAB

Heavy foliage injury from sprays and russetting of fruit in 1910 brings questions concerning necessity for use of Bordeaux mixture and possibility of substitution of lime-sulfur preparations.

In spraying for scab it is necessary to distinguish two classes of varieties of apples:

Class 1. Scab susceptible varieties, such as Rome Beauty, Winesap, Newtown Pippin, Rambo, Fameuse, and certain others.

Class 2. Varieties not susceptible to scab, such as Baldwin, Ben Davis, Gano, Stark, Wagner, Hubbardston, Jonathan, Rawles' Janet, Belleflower and some others.

Also more especially for Class 1:

- (a) Vigor and resistance of some varieties to spray treatment and of some trees under certain conditions.
- (b) Previous spray history of the orchard.

On Class 1, certainly, and on Class 2, except in case of orchards that have been regularly and very thoroughly sprayed for a succession of years, a thorough spraying with fungicides is necessary upon the new shoots and blossom clusters just before the blossoms open to control the scab.

For this first scab application Bordeaux mixture may be used without risk of serious injury on all varieties—upon Class 1, it is an efficient and safe spray for scab control; for Class 2, good

results have been secured in many cases for both San Jose scale and scab by the use of lime-sulfur, when the buds are just opening. The scurfy scale is also reached by this spray.

II. COMBINED SPRAYING FOR SCAB AND CODLING WORM

For Scab: For subsequent treatments, that is, for second spraying to be made just after the blossom petals fall, and for third spraying made 10 days to two weeks thereafter, because of liability to russet fruit, Bordeaux mixture is not likely to prove safe on Class 2; instead, half strength of Formula No. 7 (1-2-3-50 formula) or summer strength of lime-sulfur, such as Formula No. 14 diluted to 350 to 400 gallons, or commercial lime-sulfur 33°B. at the rate of 1 gallon to 40 gallons of spray, is to be preferred.

On class 1 where previous experience shows light spray injury from Bordeaux mixture and where the orchard vigor is good, little fear need be felt from use of Bordeaux mixture, and generally none at all need be felt from formula No. 7, or its half strength: where experience shows serious injury from Bordeaux mixture, the half strength of No. 7 and lime-sulfur, as above described, will be safe.

For Codling Worm: On all varieties the Spray Calendar recommendations for arsenicals added to the fungicides are required in second and third spraying. If lime-sulfur is used, arsenate of lead should be used in combination. If treatment is very thoroughly made, 2 lbs. of commercial arsenate of lead to 50 gallons of spray is generally sufficient. As spraying is ordinarily done 3 lbs. is more reliable.

III. SPRAYING APPLE TREES FOR BITTER-ROT AND BLOTCH

Where bitter-rot or blotch prevails some difference may be found as between copper sprays (Nos. 1 & 7) and lime-sulfur. The evidence seems to favor the copper sprays. However, effective control of either bitter-rot or blotch will probably require, in addition to the foregoing sprays, the summer treatments with ammoniacal copper carbonate as outlined in the Calendar under bitter-rot.

IV. SPRAYING FOR SOOTY FUNGUS

This is usually covered where a third spraying (second after bloom) is thoroughly made. The relative efficiency of copper sprays and lime-sulfur is not clearly determined for sooty fungus.

V. SPRAYING OTHER TREES AND VINEYARDS

Upon Pear trees in leaf, lime-sulfur sprays may prove unsafe.

Upon Peach trees in leaf Formula No. 10 of 10-10-50 strength is recommended as heretofore.

Upon Plums that may safely be treated in leaf with copper sprays, these will possibly be most useful; upon American and Japanese varieties Formula No. 10 is recommended.

For Grapes, lime-sulfur sprays are not reliable.

VI. SPRAYING FOR SAN JOSE SCALE AND SCURFY SCALE

In spraying for San Jose scale and scurfy scale on dormant trees with commercial lime-sulfur preparations, the dilution should be 1 part of mixture to 9 to 11 parts of water . The exact degree of dilution needed may be determined, if desired, by hydrometer test. Without test, 1 to 9 is recommended.

Ohio Agricultural Experiment Station.

CIRCULAR NO. 110

WOOSTER, OHIO, FEBRUARY 25, 1911

TREATMENT OF ARTIFICIAL TREE PLANTATIONS

By EDMUND SECREST

Artificial tree plantations of certain species in a highly specialized commonwealth like Ohio require a radically different system of management from that ordinarily applied to forest areas. With many of these plantations the same care and culture given to ordinary field crops are applicable and profitable for the first few years of their existance. Before attempting to establish a tree plantation one should resolve to give it care and remain firm in the resolution. An outlay of time and money is required at the outset, in order to insure success. One need not expect results by merely planting the trees and allowing them to care for themselves.

CULTURE

Under this head the more common trees planted throughout the agricultural regions of the state will be considered. Trees always grow faster under cultivation than in sod, or when allowed to compete with weeds and brush. Whenever possible clean cultivation gives best results, and the trees should be spaced to permit of this.- In order to facilitate cultivation and pay for the cost, a crop may be grown between the rows for the first year or two. For this purpose potatoes or legumes are best. Corn is not suitable. Cultivation may be carried on in the same manner as for any field crop, and should be started as soon as necessary after planting. The period of cultivation will vary with species and conditions, but it should be carried on as long as possible. Most species commonly grown can be cultivated for three seasons. Care should be taken the third season however, as by this time the root systems of the trees are developed, and deep tillage may destroy the young fibrous roots, and thus do more harm than good. A five or seven toothed cultivator, or spring toothed or disc harrow, are desirable implements at this time. When the rows are wider apart one way than the other,

tillage can be carried on to greater advantage, although cultivation both ways is more effective. At the cessation of this operation a cover crop may be sown. For this purpose buckwheat, cow peas or clover are desirable. The first and last can be sown in July or August and cow peas in the spring. The crop should be permitted to fall and form a mulch. This material, however, must be raked away from the trees a foot or two in the fall, in order to minimize the danger of mice injury.

In case of locusts, cultivation for more than one season is of doubtful utility, on account of the propensity of the species to throw up root suckers.

MULCHING

This system of cultivation is a valuable supplement to clean cultivation and can be utilized in cases where such procedure is impossible or impracticable. Any vegetable material may be used, but wheat straw will probably be found the easiest to obtain. The mulch material should be placed about each tree for a radius of three or four feet, leaving a space next to the tree bare for a foot or two.

PRUNING

The Catalpa. In the case of this species, judicious pruning is one of the fundamental requisites of success. The catalpa is not self pruning as are some of the common forest trees, and close planting does not serve to clear the trunks of branches. It is advisable in most cases to cut the seedlings off an inch or two above the root collar before planting, thus insuring a straight growth at the outset. This is desirable where the stems have been frozen in the nursery row, or after heeling in. Usually two or three sprouts result and all but the most thrifty should be removed after they are a few inches high. The practice of cutting the trees off after they are two or more years old should not be followed, except in special cases. The extremely rapid and succulent growth of the sprout, resulting from the well developed root system, cannot support the heavy foliage, and consequently places the entire grove at the mercy of the wind and rain storms. Many of the trees become distorted and worthless. The same condition is liable to result where all side branches are removed, leaving only the stem. Lateral branches are necessary to obtain diameter growth and diameter growth is necessary in order that the tree may support its top. The ideal tree is the one having a smooth, straight trunk. This condition cannot be obtained by severe pruning. A tree receives its food largely through its leaves, and consequently growth is dependant

upon leaf surface. The fundamental principal to be observed is the elimination of forks and the securing of straight trunks, bearing in mind that the smaller side branches are an asset rather than a detriment. They should be removed however as soon as they die.

Catalpa trees are frequently injured by freezing or by the catalpa midge (see bulletin 190) and develop three or four side branches, with no terminal shoot. If possible it is best to let one of the lateral branches form the central stem, and remove the others. When this is not feasible the entire crown may be severed, allowing a sprout from this point to form the terminal. It is necessary, in certain cases, where trees are distorted to cut them off at the ground. When such procedure is necessary all sprouts may be allowed to grow for the first season, and all but the most thrifty removed the following winter. In some cases all sprouts may be removed when a foot high, except the most thrifty, which should be staked to prevent breaking off, or becoming distorted. In other cases it may be desirable to allow several sprouts to mature. There should be no hesitancy in cutting off crooked or distorted trees, which cannot be corrected by pruning. The remaining trees will afford protection against wind and other disturbing elements.

Where severe pruning has been practiced and the trees are in danger of bending over it is sometimes advisable to strip the leaves off the top for a foot or two. The leaves should never be stripped unless such danger is imminent. When trees three or four years of age are entirely pruned of side branches they become top heavy and considerable injury may result. This practice should never be permitted.

THE LOCUST

Unlike the catalpa, the locust is self pruning and the only operation necessary is the removal of branches which form forked trunks. This procedure is important and should not be neglected from the outset. The pruning of lateral branches, as in the case of catalpa, is not only unnecessary but detrimental. As soon as the trees commence to crowd, the limbs die and drop off. The tops of the seedling trees may be cut off at the time of transplanting, but never thereafter unless injured. The spreading habit of the young trees in a grove need cause no apprehension, for in the course of time they will straighten and develop into merchantable trees.

THE OSAGE ORANGE

The species is not self pruning, and owing to its tolerance to shade the lateral branches do not die quickly when the light is excluded. Careful attention should be given to the elimination of forked trunks and the lateral branches, as soon as they die.

Because of the difficulty in pruning due to thorns, it is advisable to plant the rows farther apart and the trees closer together in the rows. Such spacing will also facilitate cultivation, which should be carried on for at least three seasons.

THE MULBERRY

The various species of mulberry are similar in habit of growth and character to the osage orange and may be treated in the same manner as prescribed for the latter. Some of the mulberries are subject to winter killing to the extent that they die entirely back to the ground. Like the osage, they are excellent for windbreak purposes, and may be used about buildings, groves and orchards for this effect.

OTHER FOREST TREES

Plantations of ash, tulip poplar, oaks, walnut, poplars and practically all of the native trees are self pruning, and the removal of dead lateral branches is usually all that is required, and in some cases this operation may be of doubtful utility. The larch and bald cypress, which are exotics, may also be included in this class. The former species is inclined to retain its dead branches and they may often be profitably removed.

EVERGREENS

The tops of pines, spruces and cedars should never be cut off. It is usually advisable to prune only dead branches. In the case of pines, this is usually quite practicable. Evergreens seldom fork, but in such event, one of the branches should be removed when the tree is small.

GENERAL CONSIDERATIONS IN PRUNING

TIME OF PRUNING

The proverbial saying, "Prune when the knife is sharp", is probably correct, although it does not seem desirable to prune in late summer. The winter months offer the most opportune time, and in most respects are the best period for such work. Many prefer the months of February and March. Wounds made at this time begin to heal quickly and have the whole growing season in which to continue the process.

TOOLS

More important than the time of pruning is the kind of cut made. The cut should be clean and smooth. Ragged wounds are almost as bad for trees as for human beings. Care should always be taken not to tear the bark of the trunk. Severing the limb too

close to the trunk is injurious and makes a larger wound. Likewise the cut may be made too far out, leaving a stub which prevents a clean bole and serves as an entering place for fungus diseases and insects.

The selection of a tool will depend upon the nature of the work. For young trees having small branches, a sharp pocket or pruning knife is very practicable. Larger limbs require a chisel, pruning shears or axe. Rightly used the axe may be found to be the most practicable of all, but it must be sharp. Various patent pruners are on the market, some of which are very satisfactory. Some are especially adapted for pruning limbs high in the tree. A chisel attached to a pole may also be used for this purpose.

The number of seasons during which trees may be practicably cultivated will vary according to conditions of soil and site.

Approximate period of cultivation for the common forest trees in artificial plantations: Locust, 1 to 2; Catalpa, Mulberry, Poplar, and Soft Maple, 3 to 4. Ash, Larch and Tulip Poplar, 2 to 5; Cypress, Osage Orange and Pines, 4 to 5; Black Walnut, and Hard Maple, 4 to 6.

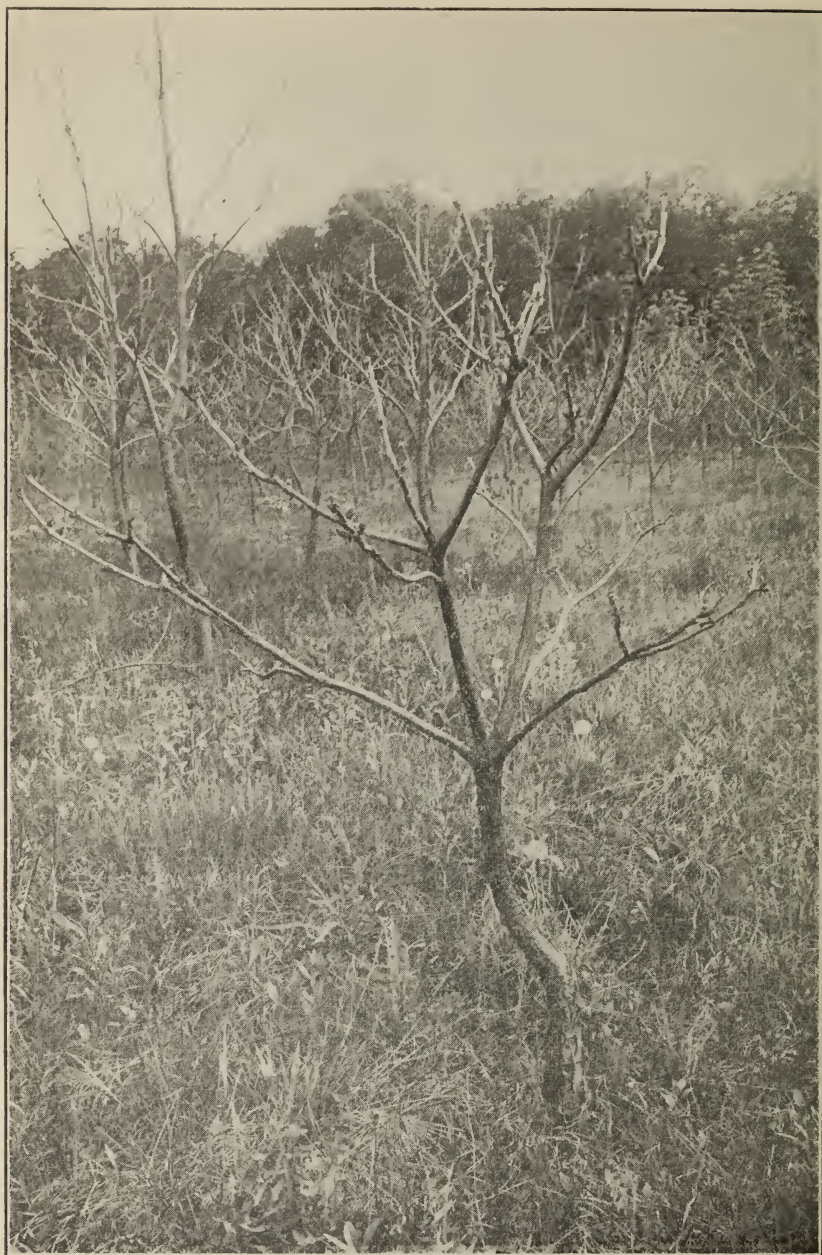
The system of treatment, especially as regards cultivation, applies only to the small farm tree plantations where conditions of agriculture demand intensive methods. In larger operations of reforestation in parts of the state they would often not be applicable.



A well pruned catalpa grove. The abundant foliage is an important factor in the rapid development of the trees



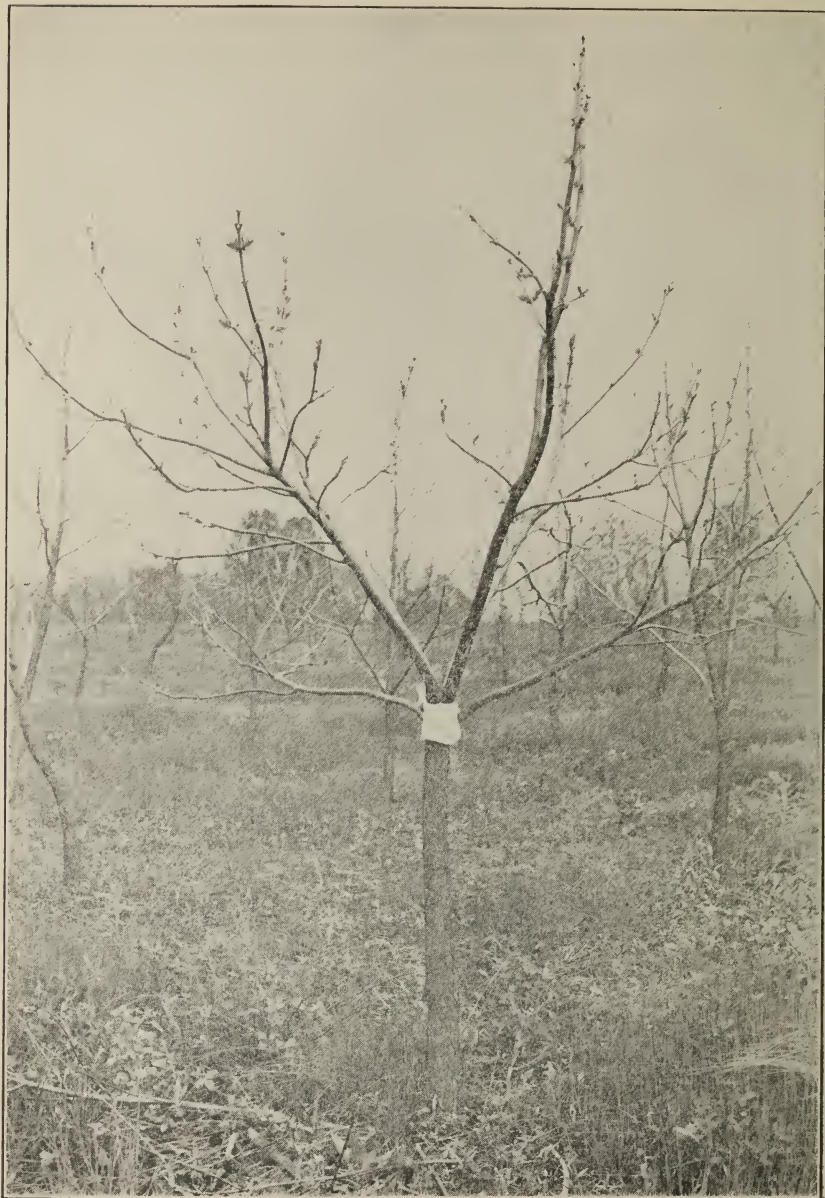
Distortion of catalpa as a result of severe pruning



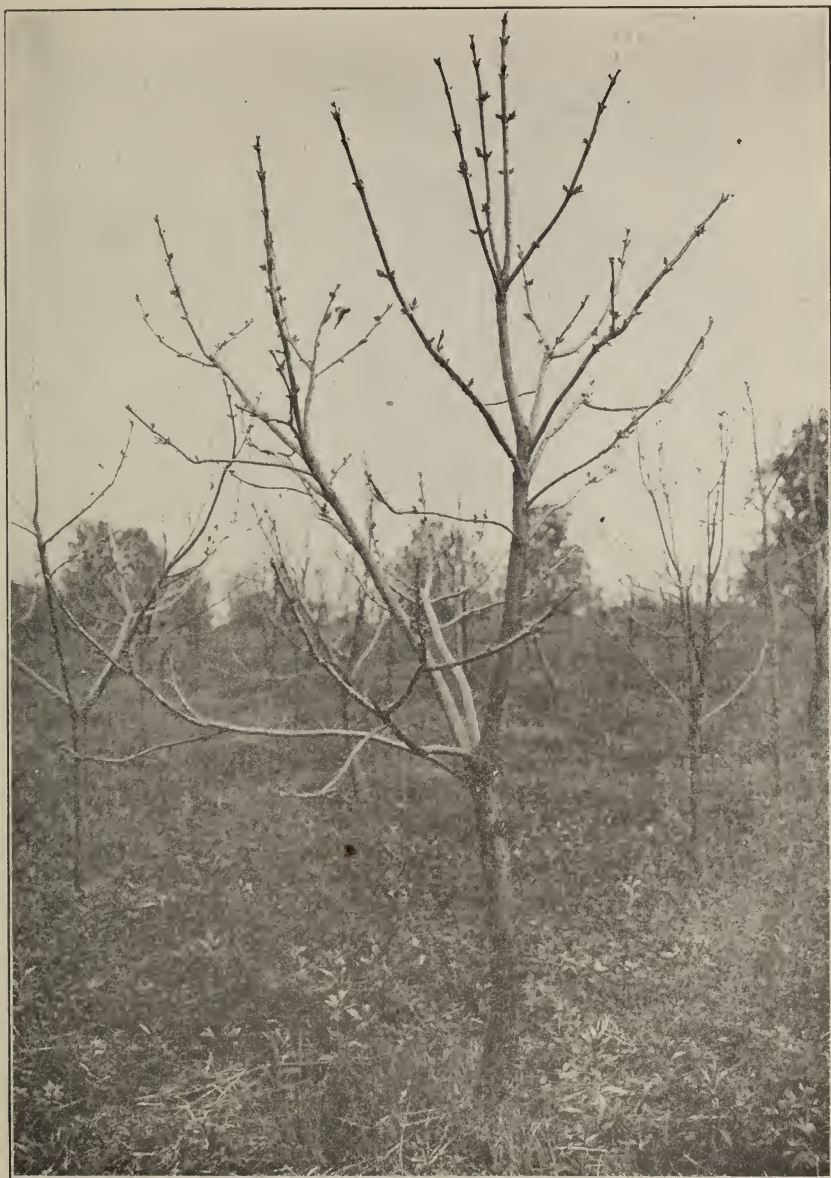
A catalpa which should be cut off at the ground. The sprout if properly cared for will be straight



A normal catalpa. One of the branches of the upper fork should be removed leaving the lateral branches to furnish leaf surface



The entire top of the catalpa tree should be severed from the trunk, at the point indicated by the cloth. The thriftiest sprout starting at this point should form the leader, thus saving the four foot trunk



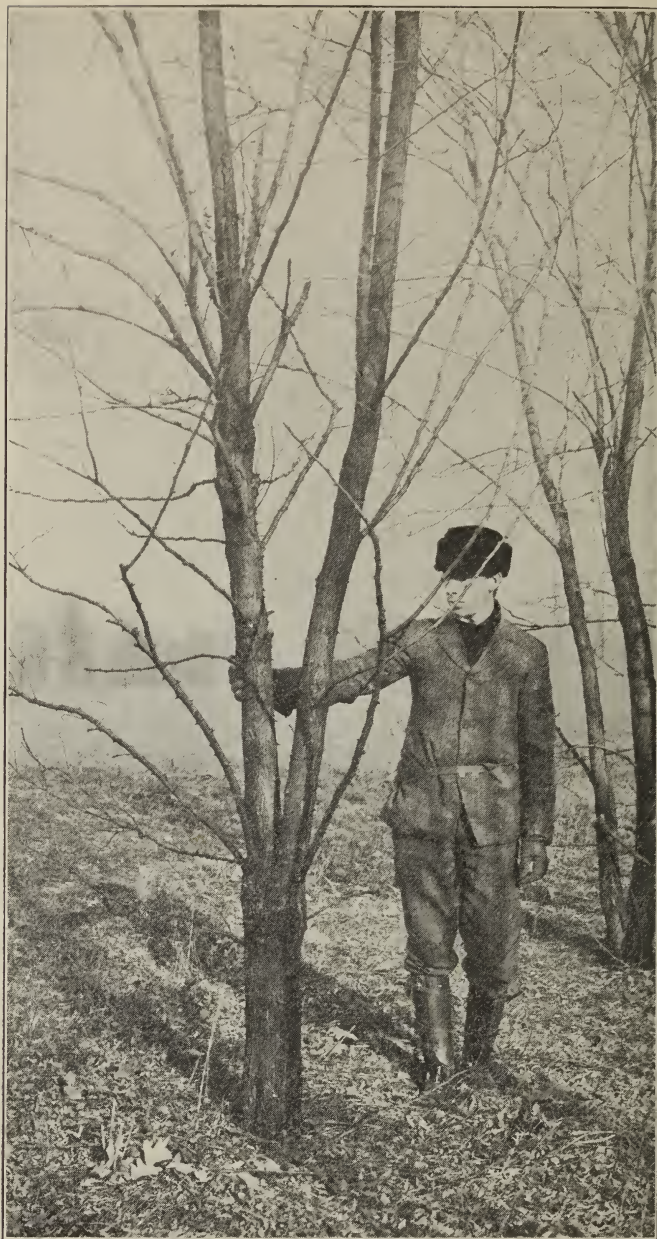
A catalpa, which may be corrected by pruning. Such trees should not be cut off at the ground



A locust plantation, in which all forks have been removed from the trees.
The smaller side branches were killed by shading, and have dropped



The wide distance of planting black locust, has permitted a spreading habit of growth



One of the branches of the black locust, forming the fork, should have been removed when the tree was two or three years old. Most of the side branches shown are dead.



Russian mulberry in the foreground, showing spreading habit of growth



An osage orange plantation. The close planting has forced the growth upward but has resulted in but little natural pruning



A white ash plantation in excellent condition. The small side branches will die and fall as the trees develop



Fig. 1. How a dead branch rots away. Decay has started

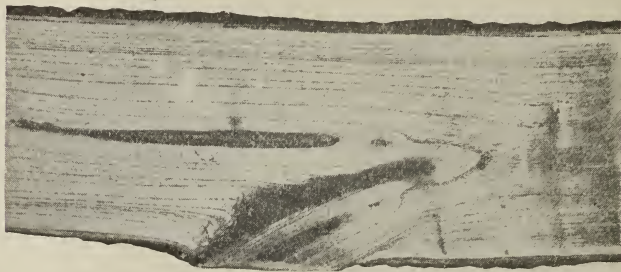


Fig. 2. How to prune a branch

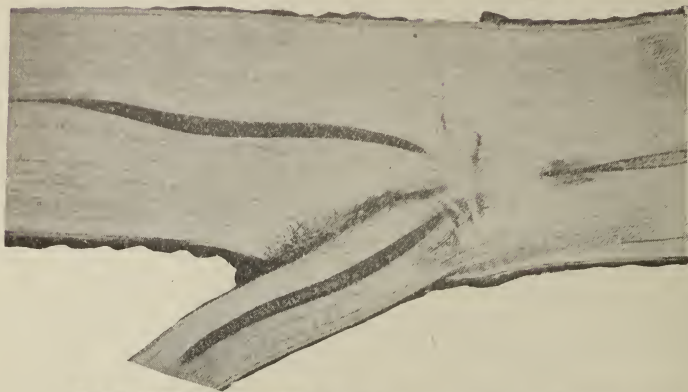
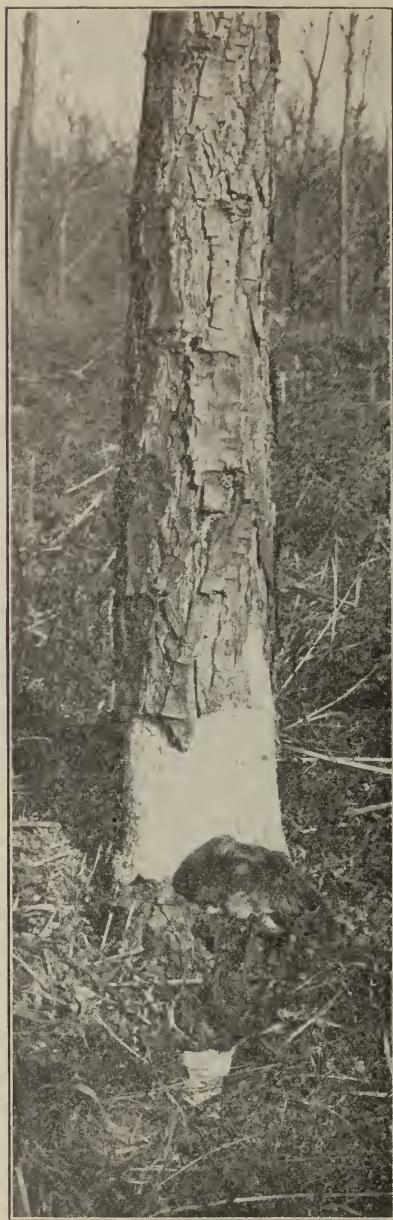


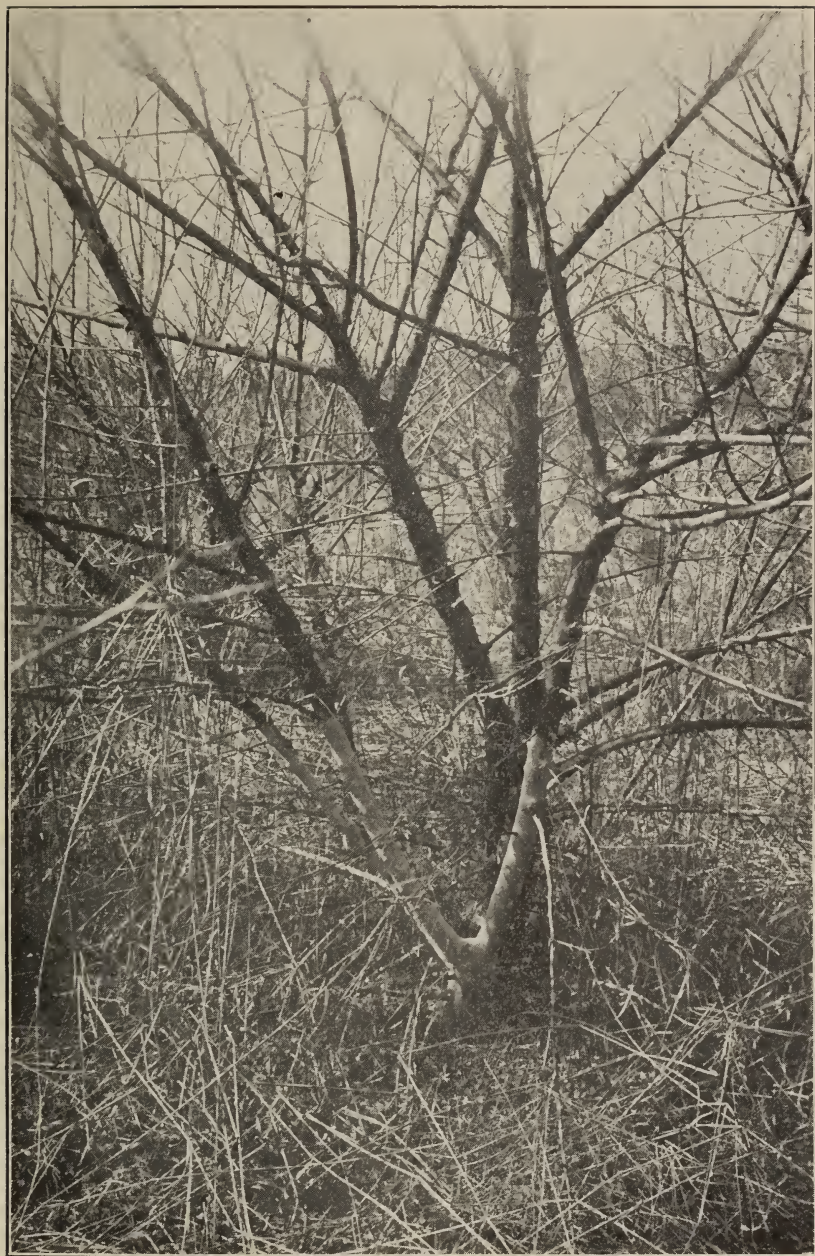
Fig. 3. Poor pruning



Catalpa plantation, (five years growth) injured by mice during heavy snow



A catalpa five inches in diameter
girdled by mice



Russian mulberry injured by mice

Oh 3c
681
Sage

Ohio Agricultural Experiment Station

CIRCULAR No. 111

WOOSTER, OHIO, MARCH 15, 1911

THE MANAGEMENT OF CLOVER IN CORN BELT ROTATIONS



SIR:—I have the honor to transmit herewith and to recommend for publication as a Circular by the Experiment Station the accompanying manuscript entitled "The Management of Clover in Corn Belt Rotations."

This paper, which was prepared by Mr. J. A. Drake of the Office of Farm Management, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Ohio Agricultural Experiment Station, is based so largely on observations made within the Corn Belt area of this State that its conclusions are doubtless applicable without qualification to that area. It would seem also that it would be more or less applicable to all parts of the State.

Respectfully submitted,

L. H. GODDARD,
Chief of Department of Cooperation.

Approved:

CHAS. E. THORNE,
Director.

THE MANAGEMENT OF CLOVER IN CORN BELT ROTATIONS

By J. A. DRAKE

INTRODUCTION

Perhaps there is no section of the country where a permanent and well arranged rotation is of so great importance to the maintenance of the most profitable system of agriculture as in the corn belt section, of which Ohio forms an important part. In connection with the kind of farming carried out on the better class of farms, the crops that are grown, and the livestock kept, such a rotation is well-nigh indispensable. The yields, by ordinary methods of farming, cannot well be kept up, much less increased, without it; and especially is it essential in the continuance of high yields of corn, perhaps the most important and most valuable crop that can be grown on the average farm in that area. The disastrous effects of growing corn continuously on the same field for a period of years without some special arrangements for heavy manuring, growing rye, etc., is beginning to be quite well understood. Experiments have shown that a mere alternating of two crops through a period of years will increase the yield of corn about one-half over that of one crop grown continuously through the same period, while the addition of clover, making a three-year rotation, has been known to increase the yield to almost three times that of continuous one crop culture.

Not only is a rotation important in crop production on corn belt farms, but it is highly desirable in connection with the keeping of most classes of livestock. Along with corn a certain amount of clover pasture and hay, or a substitute for them, must be furnished each year, and in no way can it be done with greater ease and with more certainty than to follow a regular rotation of which clover forms a part.

A regular rotation, likewise, adds system to the management of the farm. It is known definitely what is to be done each year. Each field gets its certain crop or certain special treatment in fertilizers or manures at regular intervals. This makes it possible to estimate the number of livestock that can be kept each year, and the general returns that may reasonably be expected from the farm.

Important as continued pursuance of a regular rotation is, no factor in it is so vital and gives so much trouble as the successful

management of clover in the rotation. If there is a failure of this crop, then a profitable and suitable substitute must be found, or the whole field is left idle and the entire rotation disarranged.

It was because of this important relation which the management of clover bears to the rotations generally practiced and the ever-increasing difficulty that farmers in general are experiencing in growing clover successfully, that a careful and systematic study of the farm practices relating thereto was undertaken. The problem has been an interesting one indeed, and has revealed a great many factors not at first suspected.

Rotations including wheat. Among the very common rotations found on the average farm of the section under consideration is one of which wheat forms a part. There has been for some time a tendency on the part of farmers to discontinue this crop wherever possible, but for the most part, even though it is considered uncertain and unprofitable, it is kept in the rotation because it is thought necessary or at least very desirable in getting a stand of clover.

Perhaps the most common of these rotations is that of corn, oats, wheat and clover. Another is that of corn, corn, wheat and clover. Again, another is corn, wheat and clover, this being only a three-year rotation. All of these find favor with individual farmers. It generally depends somewhat on local conditions as well as local customs as to which predominates. The first is the old rotation found on many general farms, while the second is found where it is desirable to produce more corn to feed a larger number of hogs. The third is a very useful rotation for building up a farm, especially when used in connection with a thorough system of fertilizing and applying manures.

In all of these rotations the clover is sown in the wheat. This is done at various times and in various ways. Every man has his own "best" time and method, by which he must proceed in order to be successful. Some sow their clover seed as early as February, while others wait until April with apparently equal success. There are still others who sow one-half of their seed early and the other half late and get very good results. Probably more farmers prefer to sow the seed rather early, either in February or March, being especially anxious to catch the ground in a "honey-combed" condition, or, if not in this shape, to sow on a light snow. There are many good features about this. The farmer usually gets the work done when otherwise not very busy. There is very little labor connected with the seeding and thus there is very little invested in

the crop except the seed. And, if conditions are right and everything favorable, a fairly good "catch" of clover is usually secured, but at best there is much uncertainty and a great deal of the element of chance in the average method of seeding clover which ought to be eliminated if possible.

When it is considered that for every other crop the farmer prepares a good seedbed, or at least he should, but that with clover sown in wheat it is nearly all haphazard and largely trusted to luck, we are at once impressed that a mere sowing of the seed on the wheat ground is not giving the clover a fair chance to grow and do its best. Especially does this practice become hazardous on lands that have been farmed for a number of years and have become exhausted in fertility and low in humus and vegetable matter. Under these conditions the soil becomes dead and lifeless, packs and bakes with dashing rains and sunshine, until it resembles a traveled road. There is little chance for the clover seed to become covered or even if a foothold is secured there is little hope of the young plants living.

During the progress of these studies it has been quite evident that as soil conditions change our methods of seeding clover with wheat must be changed and made more thorough. However, it is not an easy matter to introduce radical changes in present methods, with an equal assurance that farmers in general will be more successful. Nor is it the purpose of this work to urge too great changes in these methods, but to call attention to other practices which will make them more reliable and success much more certain.

Harrowing the wheat. In nearly every community where these studies have been carried on, one or more farmers have usually been found who make a practice of harrowing their wheat ground in the spring to insure a covering of the clover seed and hence a good stand. Some sow their clover seed and then harrow, while others harrow first and then sow the seed. Still others harrow, sow the seed and then harrow again to cover it. The question at once arises, will this harrowing injure the growing wheat? But the universal testimony of those who have tried it is that, especially during dry years, it is a great benefit to it. Wheat has been thoroughly harrowed as many as three times with good results. Again, will it injure the timothy sown the fall before? Some of the timothy thus sown will be torn out, but enough will live through at least two harrowings to give a sufficient stand of this crop. The clover is of so much more importance that it should have first consideration. The seeding of timothy can likewise be done in the spring with the clover.

In seeding clover after this method there is but one rule as to the time of seeding,—wait until the field is in good condition to harrow. Men who follow this method begin seeding at the earliest possible moment but are in no hurry, even sowing as late as the first of May. It is well not to put it off until the wheat gets so high as to interfere with the harrow, but sowing any time before this, if the harrowing is well done, practically insures a good stand of clover, unless the spring is abnormally dry. A good sharp harrow should be used and it should be sufficiently weighted, if necessary, to do effective work.

The greatest objection to this method is that the work must be done when the farmer is busy preparing ground for other crops, but in view of the great value of clover as a soil renewer and soil builder, together with its great importance in the rotation, this elimination of uncertainty in securing a good stand cannot be urged too strongly on farmers for their careful consideration. At least this method should hold an important place as a supplement to those already in use. For instance, where it is the practice to sow seed early, and if for some reason, as it often happens, it is discovered later that there is a very inferior stand, then more seed should be sown and harrowing resorted to. No farmer who is keeping apace with his business can afford to let a single year pass with a failure to get a good stand of clover.

Using a disk or shoe drill. In some places men were found who were using their disk drills to great advantage in sowing clover in their wheat. A few shoe drills were also used with equally good results. In using the drill for this purpose they sow the seed with the seeder, placing it in front of the grain box, or with the new type of drill they allow the seed to go down through the grain tubes and be covered slightly. This is a very effective method of getting a fine stand of clover and it does the wheat little or no harm. There is a difference of opinion among farmers as to which way the drill should be driven when putting in the clover. Some say it should go the same way the wheat is drilled, while others contend it should go across the wheat rows. Since both ways are quite generally practiced, it is very probable that either one will do very little damage to the wheat crop. Care should be taken not to force the drill into the ground too deep. All in all, the method seems to be a very commendable one which should find a prominent place in general farm practice.

Top-dressing the wheat with manure. Under normal conditions on farms where an abundance of manure is produced, rightly cared for and applied to the land at regular intervals, very little difficulty is experienced in managing the clover

crop successfully. No matter how the manure is applied, when, or to what crop, good stands are nearly always secured, which grow on to maturity without much attention or consideration on the part of the farmer; provided, of course, his soil conditions, such as drainage, lime content, etc., are otherwise favorable. Such is the case especially after several years of this kind of farming. It has been quite noticeable during these studies that on good livestock farms where the manure was properly handled, and especially in dairy sections, very little was heard of so-called "clover sickness," poor stands, etc., while on grain farms where everything has been sold off for a number of years and wasteful methods of burning stalks and trash have been practiced, the failures have been numerous and the clover troubles are increasing at an alarming rate. This last condition exists in sections where they have formerly grown clover very successfully by their present methods of management.

When the soil has become badly run down, manure will doubtless do most good when applied as a top-dressing on the wheat in which the clover is to be sown. The effects of this have been noticed in a small way on nearly every farm. Most farmers have had the experience of "doctoring up" a few of the poor knolls with a light top-dressing of manure and upon going back the next year to observe, they have usually found that there was the best stand in the field and the best clover growing. This, too, occurs where there would otherwise have been scarcely a plant of clover, or very little at most without the top-dressing. Just such a condition as this is shown in the illustration on the next page (Figure 1).

This illustration is a reproduction of a rather remarkable condition. It will be noted that the line between a very fine stand of clover and no clover at all is very marked. This line is the boundary between manure and no manure. The seed, of course, was sown over the entire field alike. A much better growth of clover could not be secured under any circumstances than was found where the manure was spread; whereas, where there was no manure, nothing existed but a very poor growth of timothy, a few stunted weeds, sorrel,* and bare ground, the bare white ground predominating.

*It might be well to state that in some sections sorrel (*Rumex acetosella*) is not common. It is found in great abundance, however, in the eastern and southern part of Ohio, and seems to be most abundant on soils of shale and sandstone origin. It is usually considered as indicating the lack of lime. This, however, should not be understood to mean that an application of lime will kill it, except as it might cause clover or other dense-growing crops to grow more vigorously and smother it out. It has been found growing vigorously in the edge of a pile of pulverized limestone. Sorrel should not be taken as an absolutely certain indication that an application of lime is entirely necessary for the growing of clover without some further investigation along this line by experimenting with lime itself. The other factors, such as methods of seeding, applying manure, etc., which are being set forth in this circular, ought to be studied also in this connection.

Where the manure was spread it was very noticeable that all of the sorrel had disappeared and nothing but clover grew. The clover had so thoroughly taken possession of the soil that the sorrel had been completely smothered out, proving that the smothering out process is one and possibly the only successful way of getting rid of sorrel. Anything that makes clover or other crops grow so thickly and so vigorously that the sorrel cannot exist will kill it out. In this case the top-dressing of manure has accomplished this result completely by producing a perfect stand and maintaining it.



Fig. 1. The effects of a top-dressing of manure.

To the right of the picture will be noted a narrow strip of clover which dwindles out to almost nothing. If the picture had been extended a little further to the right it would have shown a narrow patch of clover which gradually disappears and which marks the path of the farmer as he was driving away from the scene of action, and some of the manure sifted down through the "dump boards" or rough wagon bed in which the manure had been hauled. As far as this sifting process continues the clover follows the path of the wagon, but as the manure gives out the clover entirely disappears.

This very pronounced condition found on a poor knob of a run-down farm is an eloquent appeal for the continuance of livestock and more manure, better cared for and applied. One farmer was not far wrong in his answer to the question often used in making these studies, "Do you have any trouble in getting a stand of clover?"

when he replied, "Not since the manure spreader came on the farm." It is needless to say that he top-dressed all of his wheat ground carefully wherever he expected to sow clover. It might be added that in general practice this is done immediately after the wheat is sown in the fall, or during the early part of the winter.

Spreading straw on wheat ground. A very interesting and unusual practice in connection with the management of clover in rotations including wheat, is to spread straw evenly over the surface of the soil after the wheat is sown and before it comes up. In the absence of suitable straw spreaders the farmers haul the straw out in small piles and spread it by hand. On the poorest spots whatever manure is available is used, but on the remainder of the field straw is spread with as much care as though the work were being done on strawberry beds. The following illustration gives an idea of such a coating of straw through which wheat has come up, as well as the appearance of a field in which this practice is carried on.



Fig. 2. A close view showing covering of straw on wheat field.

This unique practice is found in a section where clover growing in a wheat rotation is a very uncertain undertaking indeed. In these localities the best farmers are resorting to this method as apparently the last extreme. This is necessary to grow clover and be at all successful. Those who consider this practice not worth while or too laborious have about quit trying to grow the crop at all,

so numerous and constant have been their failures. The soils on which these conditions are found have been farmed for a great number of years with no thought or provision for keeping up the humus and decaying vegetable matter, and as a result the surface has become so hard and lifeless that without some special provision like the covering of straw or manure the young clover plants cannot take root and maintain themselves sufficiently to give anything like a satisfactory stand. The photograph was taken about May 1st, and wherever there was a slight covering of straw, something to give some protection and hold the moisture slightly and prevent the ground from baking, there the young clover plants were to be found in great numbers and growing with great vigor. But where there was no straw and the soil was bare, in no case was clover found growing. On this farm the clover seed was sown at any time in March when it was thought that the conditions were right. No special attention was given. The seed was sown broadcast as it is usually done by farmers. During the past summer the writer has had occasion to visit this farm again after a lapse of about three years, and better success with clover every successive year is reported. A failure to get a stand has not been experienced for some twelve years. This is extremely interesting as other farmers in that section have failed to get good stands unless it is by this method or by the scattering of manure, which is, of course, as good or better. That this man is successful in growing clover by this method is shown by the accompanying photograph, Fig. 3, which was taken on adjoining fields similarly treated the year before.

The practice of spreading straw in order to get a stand of clover is not so valuable as something to be recommended to farmers to practice, as it is in what it teaches. It may be objected at once that it is a mulch, and true, it is. It may also be objected that it is an expensive practice from a labor standpoint. Whether this is true or not may be judged from the fact that the man and his hand were able to haul and spread the straw over three acres per day. If suitable straw spreaders were at hand this labor might be materially reduced, but as it is, and under the conditions found, it is time well spent. The practice, however, is worthy of very careful consideration and study. It is found on land where clover had once been grown without any difficulty whatever, but years of farming has brought the soil to that state where a mere thin scattering of straw on the surface will insure a perfect stand of clover, while without it, or some substitute like manure or the equivalent of trash, leaves, etc., clover cannot be grown. The natural drainage is good. Commercial fertilizers have been used abundantly for years and there

should evidently be no lack of the elements essential for plant growth. There is no lack of lime, the soil in fact being for the most part of limestone origin. But under these conditions it lacked what proved to be a most essential factor to success in clover production; namely, something that will have an effect probably similar to that of an abundant supply of humus and vegetable material incorporated in the soil. It is not the intention to advise this method of applying straw to wheat ground as a general practice, but merely to call attention to the wonderful effect it has had and to bring out the fact that to grow clover on such soil it is necessary to do something for it that will enliven it, cover more seed, prevent baking and cracking, and conserve the moisture. It might be well to add, also, that it suggests a much better means of disposing of straw and stalks than burning or selling them on the market, and it ought to give the average farmer a glimpse of the extreme value of the accumulation of any vegetable matter such as straw, stalks, trash or leaves, especially on the surface of the soil, in connection with getting a stand of clover.



Fig. 3. Stand of clover secured by applying straw to wheat field.

It would seem very probable from this that a condition might arise wherein the extreme lack of humus and organic matter is the principal and perhaps the only element of failure with the clover crop. How prevalent this condition is, investigations have not been carried far enough to say. But farmers, in limestone regions

especially, may well consider the humus problem as one of their important factors in clover growing. The extremely unfavorable condition for young clover on a hard, compact, run-down soil is something that can not easily be over-estimated. The tendency has been in the past to ignore the great value of humus and organic matter in the production of profitable crops of any kind, and it is very probable that the increasing amount of clover failure on soils that have been farmed for a great many years is due to the gradual but certain exhaustion of humus and vegetable material, which constitutes one of the greatest factors of the soil's physical make-up.

The adoption of better methods of farming, and of rotations containing special features for supplying to the soil an abundance of humus-forming material, would doubtless soon put an end to much of the failure with clover in a corn and wheat rotation over a large part of the section where such failures now occur. This, together with better and more careful methods of seeding, and a better preparation of the surface of the soil, which has already been discussed, seems especially advisable. The seed must be covered by one means or another, and the surface of the soil should be either thoroughly pulverized or have an abundance of humus or a temporary substitute for humus in the form of a mulch or covering on the surface. Unless these conditions are supplied the young clover plants can not get a foothold and maintain themselves in their earlier stages of growth. If the surface of the soil is too hard and dries out too readily the young clover nearly all dies out before it gets even a fair start. This fact seems to have been generally overlooked by the great mass of farmers. The physical condition of the soils on many farms is continually growing worse. They are becoming more lifeless and less friendly to young clover from year to year.

Farmers are urged to consider its importance and to do all in their power to correct the evil. The hard, compact condition of the surface soil in the spring, with its tendency to bake and dry out must be overcome. Supplying humus and vegetable material as rapidly as possible will accomplish this result. As this is done perhaps one of the most common causes of clover failure will be removed. Until this is done there will be great need of pulverizing the surface and breaking up the surface crust by the use of some such implement as the harrow or drill.

Rotations containing cowpeas and soybeans preceding wheat. In the southern part of Ohio a very interesting practice was found. Some of the farmers have adopted rotations in which cowpeas or soybeans come in just before the wheat crop. It is the usual practice to make the crop into hay in time to have the ground ready for fall seeding, but occasionally the entire crop of cowpeas

or soybeans is rolled down and crossed with a disk in the preparation of the ground for wheat. By using a disk drill the wheat can be sown without any inconvenience because of the litter on the surface of the soil. The accumulation of cowpea and soybean vines on the surface of the ground serves as a mulch very much on the order of the straw just discussed, and is very helpful in getting a stand of clover. In fact, it only emphasizes again the great value of some accumulation of vegetable matter on the surface of the soil to keep it in better condition for the growing of the young clover plants. The nitrogen furnished by these crops is also a great stimulus to the wheat as well as to the clover throughout its growth. The practice of turning the entire crop back to soil, however, is somewhat wasteful. If it could be so arranged as to have the peas and beans ripen early enough it would be better economy to gather them with hogs, thus allowing only the vines to fall back to the soil. This would accomplish the same results in reference to the stand of clover, besides getting the value of the crop in pork.

Rotations including rye. Rye is becoming more and more popular as a crop in the rotation in which clover is sown. It has some points of advantage over wheat in that it grows taller and less dense and does not shade the clover so much as wheat. The methods of seeding clover in rye are much the same as in wheat. The seed is sown in the spring by the usual methods. Harrowing the rye can be resorted to the same as on the wheat crop. Farmers have also been found who use a disk drill and even a disk harrow in breaking up the surface of the soil so as to secure a covering for the seed when sown in the rye crop. The use of a disk harrow can be resorted to on rye, but it is rarely ever done in connection with wheat. Even with rye it should be set straight so as not to do much damage to the rye crop. If this is not thought desirable or possible the seed may be sown and hogs turned in for early spring pasture. The tramping of these animals over the field will plant much of the seed in the ground and make a good stand more certain. A top-dressing of manure or a covering of straw can be used with the rye the same as with wheat. The use of a good commercial fertilizer on rye, the same as on the wheat crop, will often prove very beneficial in securing a good stand of clover, and in the absence of manure, the value of which has already been discussed, the use of a good commercial fertilizer is very commendable. This will often insure a good crop of clover where otherwise there would be a failure.

The rotations followed, which include rye, are usually on the same general plan as those including wheat. These are usually corn, corn, rye and clover, or corn, rye and clover. Some of the

potato growers have a rotation of potatoes, rye and clover, running it as a three-year rotation, while others run it as a two-year rotation, clipping the rye and clover about three times but taking no crop off. The next year, then, potatoes are planted after the clover has had time to make some growth in the spring, for what is called the late crop of potatoes. In a similar manner a two-year rotation of rye and potatoes can be practiced, and the rye hogged down when ripe, the clover being sown in the rye in the spring and allowed to grow up before the ground is plowed for potatoes the next year.

Rotations with oats. Some farmers run a rotation in which oats is the only crop in which the clover is sown. Such rotations are usually corn, corn, oats and clover, or corn, oats and clover. With these rotations failures in securing stands of clover are rather numerous, but some men are quite successful in the management of the clover crop even under these circumstances.

If a good stand of clover is particularly desired, one of the first things to be avoided is a very heavy seeding of oats. Lighter seeding will probably cut down the yield of oats somewhat, but the chances of a catch of clover will be very much greater. Not over a bushel and a half of oats per acre should be sown, whereas it is generally the custom to sow from two to two and a half bushels per acre. Oats at best is a bushy crop and produces a very dense shade under which the clover is not likely to thrive. Then too, when the oats crop is taken off the clover is exposed to the sun very suddenly and sometimes damage is done in that way; especially is this likely to happen where the shading has been very heavy. However, with proper methods of seeding and watching this one point, very satisfactory stands can quite frequently be secured in oats.

Rolling the oat field after the clover seed has been sown is considered by many farmers to be of great importance. This covers the seed just about deep enough and firms the surface of the soil in such a way as to insure a good moisture supply to the young plants. Some prepare the ground and sow the oats with a drill, and the clover with the grass seeding attachment, allowing the seed to fall back of the hoes or disks. The roller is then run over the field. Others sow the oats either with the drill or broadcast, using the roller to cover the seed. The beneficial effects of the roller on the clover is very marked where the soil is in fit condition for rolling. It usually insures a good stand which is quite uniform on the ground.

Another very good method of seeding with oats is to sow in stalk ground and allow the stalks to remain on the surface of the soil. This again is only a repetition of, and brings again to our

notice, the value of the accumulation on the surface of the soil of some protection in the form of vegetable matter, which will prevent the baking and drying out of the soil. In doing this the stalks are usually broken down and the ground disked, after which the oats are sown and disked in. If the stalks are not too large and are well cut up a disk drill can be used, but the former method is most generally practised. The clover seed is sown after the seeding of the oats and the roller in this case also should be used. This, together with the great protection which the stalks furnish, practically insures a good stand. A great many farmers have been visited during these investigations who follow this method exclusively and very rarely fail. The following illustration shows a field which has been sown after this method, although the rolling was omitted.



Fig. 4. Corn stalks on the surface of the soil where oats and clover have been sown.

In the field shown in the above illustration it was very noticeable that wherever there was a slight accumulation of stalks or corn husks on the surface to hold the moisture and serve as a slight shade and protection, the young clover was getting a much more vigorous start than it was in the open ground where exposed to the full force of the wind and sunshine. The folly of raking and burning such litter, as is sometimes done, should be at once apparent. Not only is it greatly needed in the soil but as a surface protection

for the clover crop its value cannot be too highly appreciated. The accumulation of litter in the way of stalks, straw, manure, etc., on the surface of the soil in getting a stand of clover should be considered as something of vital importance by all farmers.

Rotations of corn and clover only. Only a few instances of corn and clover rotations have been encountered. These were usually corn, corn and clover, or two years of corn and two of clover. The clover in such rotations is either sown in the corn at the last cultivation or by itself in the spring without a nurse crop. Both of these methods have several objections for the use of the average farmer. The first one, seeding in the corn at the last cultivation is, under ordinary conditions, very uncertain. However, on rich black soils, some farmers were found who, being especially careful to have their corn ground in "onion bed" condition at that time, were very successful, rarely ever missing a stand of clover. But on average clay upland soils and with the cultivation the average corn field receives, especially in a dry year, seeding in the corn is a very uncertain undertaking indeed. Such a method cannot be advised for the average farmer except as he experiments with it in a very small way and finds out what results he may expect.

As for the second method of seeding in the spring without a nurse crop, in some sections they have found that it is a very certain method of getting a good stand of clover. However, it is not to be advised on fields which are badly infested with weeds, unless provisions are made for one clipping. If the conditions are favorable in this respect, and the seed is sown rather early in spring, even after one clipping, a good crop of hay or seed can usually be cut sometime during August or early September. If hay is cut and the crop not allowed to go to seed the field can be left in clover another year.

Lime applied in the rotation. Without the presence of a certain amount of lime in the soil, no matter what the rotation may be or how thorough the method of seeding, the clover crop will not do well. Most soils, however, in limestone and limestone-glaciated regions, usually have an abundance of this element to grow clover successfully. But again, there are other soils, such as are found in sandstone and shale regions, which were not abundantly supplied with lime in the beginning or in their virgin state. When such soils have been farmed for many years the numerous crops, and more particularly those of clover, have drawn heavily on this supply and in many instances have reduced it to the point where a full crop of clover cannot be grown. In extreme cases even though manure be applied it will produce perhaps only a half crop or less as compared with the same land on which lime is supplied with the manure, or

preferably in advance of it. Nothing can take the place of lime in some form where lime is really needed, and there seems to be no way out of it but to apply the lime to the soil.

This condition, however, may vary on different farms in the same community on the same soil formation, depending on the treatment given and the kind of farming carried on in the past. It is always well, therefore, to make sure that this need is apparent, and the only test which a farmer should consult in this is to make an application of lime on small sections of a field at different rates (perhaps a half ton, a ton, and one and a half tons per acre) and see for himself whether it produces an increased growth. If ground limestone is used in place of lime the amounts should be doubled. If it gives results then it is safe to plan for further and more extensive applications to the rest of the area that is in a similar condition, at the rate indicated as necessary by the test. If, however, no difference can be detected between the clover where the lime was applied and where it was not, even at the heaviest rate, it is fairly good evidence that it will not pay to use it. If it is found unprofitable it is poor business to use it, but if it is found that lime is really needed it is likewise very poor business not to use it and its application should not be delayed.

After the first preliminary experimenting with lime to ascertain its value, in general practice it is best to apply lime on the corn ground, whether the rotation is that with wheat, rye or oats for a nurse crop. The same is true if the clover is sown in the corn at the last cultivation or following corn the next spring without a nurse crop. When the lime is sown on the corn ground the cultivation of this crop stirs it into the soil in a very thorough manner, more so than would be the case if it were applied when the ground is being prepared for the wheat, rye or oats crop. Lime, however, can be applied at this time with good results, provided it is not convenient to do so on the corn ground.

Value of clover in the rotations. No rotation is complete without clover. It is the crop that supplies nitrogen to the soil, the most expensive element when it is bought in the fertilizer sack. Clover brings up the mineral elements, phosphorus and potassium, from the sub-soil, and stores them in the large surface roots and crowns to be used later by other crops. It has been estimated that a good crop of clover on one acre has in its roots and tops elements of fertility equal to that contained in ten tons of manure, the roots alone containing about one-third to one-half of that amount. It is extremely important to keep the soil well supplied with humus and decaying vegetable material, and this the clover crop does by filling it with an immense root system. The value of this feature it is not an easy matter to estimate.

Farmers in general are apt to continually underestimate the full significance and the extreme importance of this crop. However, its real and immediate value is so great, and its continued success means so much in keeping up the rotation, and the rotation so much toward keeping up a continuous and profitable system of farming, that every effort should be made and every means applied to make sure that each year there will be success in growing clover and maintaining the rotation as planned.

SUMMARY

On the average farm success in maintaining a profitable system of agriculture hinges very largely on keeping up a systematic rotation.

No rotation is complete without clover or some legume as a substitute for it. Hence the importance of continuous success with clover.

Continued success with this crop is a very broad problem. Failure may be due to one or more of a number of factors. Assuming that the land is well drained, and that a liberal amount of seed is to be sown, the following points are of extreme importance:

The method of seeding. The seed must be covered; the soil at seedtime must be in condition to insure this, and if not, the conditions are not favorable for germination and for the young clover plants taking root. If the common method of sowing on "honey-combed" ground or on the snow, in winter grains, does not afford this covering, a seed bed should be prepared by the use of a harrow, disc drill or even a disc harrow. The seed will thus be covered and moisture conserved to insure further growth. It may be necessary under some conditions to sow clover in the spring without a nurse crop, and after a careful preparation of the seed bed.

The top-dressing of manure. With only the ordinary method of sowing clover on the frozen ground or on snow, even on some of the poorest lands, a top dressing of manure will most generally insure a good stand. (See Figure 1). On run-down lands, and where only a limited amount of manure is available, this is doubtless one of the best ways in which manure can be utilized.

A mulch of straw. (See Figure 2). When sufficient manure is not available, a mulch of straw will prove very effective. If there is a slight covering of straw, leaves, stalks or other vegetable matter on the surface of the soil, it will usually insure a good stand of clover and maintain it throughout the season. Such a covering holds moisture, prevents undue baking and cracking of the soil and is a great protection to the young clover crop. (See Figure 3).

Humus and vegetable material in the soil. The depletion of organic matter in the soil, and its immediate effects, are doubtless responsible for many of the increasing clover failures. In its absence the soil becomes compact and lifeless, crusts and cracks and moisture escapes very rapidly, thus furnishing a very unfavorable condition for the growth of clover in its early stages. Most soils when new, and as long as properly handled thereafter, have an abundance of vegetable matter in them, and little difficulty is experienced in getting a stand of clover, but with years of continuous cropping this becomes used up and a change takes place in the soil, very largely due to this fact, which makes clover growing more and more uncertain. A decided effort should be made to correct this deficiency.

Lime. Most soils have sufficient amounts of lime to insure a good growth of clover if other conditions are favorable, but some soils are naturally low in their lime content. On such soils many years of cropping sometimes reduces this lime to a point where a profitable crop of clover cannot be produced. The surest and safest way for the average farmer to find out whether his fields need lime is to apply lime to a small area and watch the results on the clover as compared with no lime. Sorrel should not be taken as a certain indication that lime is needed. It will grow in the presence of an abundance of lime. Applying lime will not kill it out, but a rank growth of clover or some other similar crop will usually accomplish this.

When a farmer begins to experience failure with clover, he should avoid jumping at conclusions and saying that any one factor is the cause. It is a broad field for him to think upon and to work out, and one indeed in which there are many factors to be considered. These investigations may very probably have only touched a few of the most important of them. This report is submitted, however, to the farmers of Ohio, in the hope that it may rouse a greater interest and more careful thought on their part, and thus develop further solutions of the problems in connection with this extremely important crop.

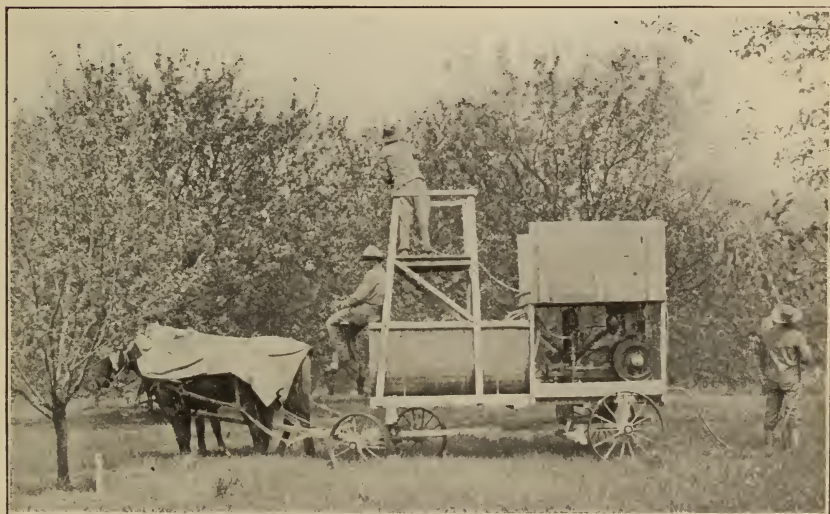
Ok 3c
safe
1881

Ohio Agricultural Experiment Station

CIRCULAR No. 112

WOOSTER, OHIO, APRIL 30, 1911

COMMERCIAL APPLE ORCHARDING IN OHIO



Spraying in the Station apple orchard

Photo by Beeching

COMMERCIAL APPLE ORCHARDING IN OHIO

By H. A. GOSSARD

In 1907 the writer commenced a series of apple spraying tests in Ohio to determine if western methods of spraying could be adapted to Ohio orchards and what combinations of chemicals were best suited to our conditions. An account of the results of the work for the season of 1907 was given in Bulletin 191 and excited widespread interest. From 12 acres of bearing trees less than 20 years old, 2,500 bushels of apples were picked, most of them being sold at \$3.50 per barrel, the buyers furnishing the barrels and doing the barreling. Several hundred bushels were sold at \$1.50 per bushel. About 25 acres in total of bearing apple trees were possessed by Messrs. Schmitkons and from these were harvested that season approximately 4500 bushels of apples which yielded a gross return of \$4,800.00. The net return for the year was easily over \$4,000.00, over one-half of which was due to spraying, as proved by the comparative results from sprayed and unsprayed trees on which careful records were kept.

The following year we continued our experiments in an orchard of 14 acres belonging to Mr. J. A. Stokes and located near the village of Erlin in Sandusky county. The results of this test were detailed in Circular 95 and excited much attention and comment throughout the eastern states. Some of our Ohio orchardists had known for years that the possibilities of apple production in Ohio compared favorably with the best in the world, but, for the first time, apparently, the masses of Ohio fruit growers began to suspect that they did not need to go to the far west in order to produce the highest quality of apples in as great quantities per acre as could be produced in famous apple districts elsewhere. From this orchard of 14 acres was gathered 1,650 barrels of fruit, besides which, from 200 to 300 bushels were sold locally as summer apples at the nearby towns, to neighbors, etc., a carload of drops was sold in bulk at 65 cents per 100 pounds and a considerable quantity was made into cider. The gross income from the orchard for the season was approximately \$7,400.00. It is a very conservative estimate to say that from \$5,500.00 to \$6,000.00 or more of this return was net and that the average net return per acre was between \$400.00 and \$500.00. From 55 Ben Davis trees, 24 years old, were picked 396 barrels of apples. Since these trees were 33 feet apart, each way, 40 trees should be allowed per acre. The average yield per tree

was 7.2 barrels, or an acre at this rate yielded 288 barrels. On an average, seven-eighths of these or 252 barrels were classed as "firsts" and sold at \$5.00 per barrel. One-eighth or 36 barrels were classed as "seconds" and sold for \$3.00 per barrel. All of this barreled product was put in cold storage in Cleveland and sold at spring prices. The value of the drops ran about \$1.00 per tree. The total receipts therefore from this acre was \$1,408.00 as closely as can be estimated. After making all allowances for care, spraying, trimming, harvesting, barreling and storing, the net profit exceeded \$1,000.00 from this acre and this with only ordinary packages and methods of marketing. There was no selection of trees nor "gerrymander" of any sort to get this acre. Every Ben Davis tree in the block with the exception of one replant, too young and small to be fairly considered, was included in the count, and the estimate was computed from one and three-eighths acre and not from less than an acre. The writer and Mr. W. H. Goodwin were present during nearly the whole of the apple harvest and can vouch for the correctness of the record. The striking results obtained in these experiments stimulated all the agricultural educational agencies in the state to increase their facilities for carrying forward orchard demonstration work, and contributed much to the revival of apple orcharding in Ohio. The most successful demonstration tests since made have employed substantially the same methods of application of the sprays that were used in these orchards.

SUBSEQUENT TESTS

In order to determine how far these results were to be considered representative or far exceptional, I decided to begin the next year a series of long term tests, using the same orchards through a succession of years so as to secure an average result, and thus give to the prospective orchardist some reliable basis upon which to compute the probable returns on an orchard investment.

The three Departments of Horticulture, Entomology, and Botany arranged a cooperative program in 1909, by which it was hoped to carry spraying demonstrations into several different localities of the state and at the same time determine what combinations of sprays were best suited to Ohio conditions. Questions relating to rejuvenation of old orchards and other distinctively horticultural problems have, so far as possible, been left to the Horticultural Department and those relating to fungous diseases and fungicidal sprays to the Department of Botany, but in the nature of the case each of the Departments has been obliged to trespass to some extent upon the distinctive spheres of the other two. For instance, we have had to do considerable rejuvenation

work in some of the orchards we are testing to put them in any sort of condition to stand a commercial test. The only orchards which were in condition to show from the beginning the true commercial possibilities of Ohio orcharding were those belonging respectively to the Messrs. Schmitkons, to Mr. Stokes, and to the Experiment Station. All these had been cared for with skill and intelligence for several years previous to the commencement of our experiments in them, having been manured, pruned, mulched, and sprayed with barrel outfits or compressed air machines, as a regular practice. These were, therefore, ready to respond at once to thorough spraying with power outfits.



Sound 2,890

Wormy 15

Wormy .51 percent

Sound 16 bushels

Wormy 1-12 bushel

Baldwin. Schmitkons orchard. Sprayed twice with lime-sulfur followed with arsenate of lead. Sprayed again with arsenate of lead in late July



Sound 1,181

Wormy 20

Wormy 1.6 percent

Sound 9 bushels

Wormy 1-8 bushel

Ben Davis. Schmitkons orchard. Two sprayings after bloom with lime-sulfur and arsenate of lead and again with arsenate of lead alone in late July

NOTE: In all cases illustrations show only the crop of picked fruit, while numerical records include drops or windfalls in every case.



Sound 1,021

Wormy 1,081

Wormy 51.4 percent

Sound 8 bushels

Wormy 7 bushels

Ben Davis. Schmitkons orchard. No poison spray

RECORD OF SCHMITKONS ORCHARDS

The Schmitkons orchards in Lorain County have the following record for the past four years:

NUMBER OF ACRES IN BEARING, 25

Year	Approximate number of bushels produced	Approximate gross income	Approximate gross income per acre
1907	4,500	\$4,800.00	\$152.00
1908	1,500	1,000.00	40.00
1909	4,000	3,000.00	120.00
1910	3,500	3,500.00	140.00
Average result per year for 4 years	3,375	\$3,075.00	\$113.00



Sound 1691

Wormy 26

Wormy 1.51 percent

Sound 12 bushels

Wormy 1-10 bushel

Ben Davis. Schmitkons orchard. Two sprayings after bloom with Bordeaux and arsenate of lead. Sprayed with arsenate of lead only in late July

These orchards are planted in a rather sheltered location about five miles from the shore of Lake Erie on quite low land. Without tile drains which are regularly laid through these orchards, the

ground would be far too wet to bring any sort of satisfactory results. Many Ohio orchards which are doing little or nothing are better located, and with the same sort of care would make as good or better records. The light crop of 1908 was probably due to a prolonged drought coinciding with the heavy crop of the preceding summer. The results given are below, rather than above the real returns. After allowing for the expense of trimming, spraying, mulching, picking, barreling and storing, fully 70 percent or more of the gross returns are certainly to be counted as net. The owners of these orchards keep bees which practically insure proper pollination of the blossoms.

RECORD OF THE STOKES ORCHARD

The record of the Stokes orchard of 14 acres for the past three seasons is approximately as follows:

Year	Approximate number of bushels produced	Approximate gross income	Approximate gross income per acre
1908.....	5,600	\$7,400.00	\$528.50
1909.....	4,000	4,666.67	333.33
1910.....	5,660	5,962.84	425.92
Average result per year for 3 years.....	5,086	\$6,009.84	\$429.25

For the years 1909 and 1910 I have only the yield in bushels and from this have estimated the income, assuming the average price to have been \$3.50 per barrel. Mr. Stokes expressed a preference that the exact returns in cash be not reported and we deem the estimate given sufficiently accurate for our purpose. I have good reasons for thinking it to be well within the actual returns. Since a considerable part of these apples were put in cold storage each year, thereby increasing the expense of handling, I will, for safe measure, deduct 35 percent for expenses and estimate 65 percent of the returns to be net. The record given does not take into account several hundred bushels which were used in 1909 for making cider. That year there were enough more than given in the estimate to make 20 barrels of cider. Of the total yield for 1910, 700 bushels were cider apples, which I have included in the estimates as being worth 25 cents per bushel.

In 1909 a solid acre of Baldwins was selected and a record was made of the yield from the 40 trees, all trees in the block, both good and bad being included. The yield from this acre was 265 barrels, or a little short of the record of 288 barrels picked the preceding year from the Ben Davis acre. At \$3.50 per barrel, the gross earnings from this acre were \$927.50 and the net return must have been easily \$750.00 or more. These orchards are well located on

strong soil and have been given excellent care from the time when they were first planted. They well represent the high possibilities of Ohio orcharding if careful attention is given to all phases of the business from the beginning of the orchard. These and many other Ohio orchards, if similarly treated, will compare very favorably with the best orchards in any part of the United States. Mr. Stokes is also a bee-keeper.



Ben Davis. Stokes orchard. Two sprayings after bloom with
 Bordeaux and arsenate of lead
 Sound 3,180 Wormy 88
 Sound 18 bushels Wormy 1-2 bushel
 Total wormy 2.69 percent
 Wormy apples in the basket



Ben Davis. Stokes orchard. No poison spray
 Sound 3,662 Wormy 439
 Sound 16 1-2 bushels Wormy 1 1-4 bushels
 Total wormy 10.7 percent
 Wormy apples in the baskets and the small pile

For the past two years the Department of Entomology has sprayed the orchard of the Experiment Station, making special use of a 6-acre block, 16 or 17 years old. This block is situated on rather high ground and the effect of the prolonged drought in the summer and fall of 1908 showed itself plainly in the light crop of 1909. This is a variety orchard, not wholly suited for a commercial test, and will be sprayed the coming season and in the future by the Department of Horticulture. This orchard, like the two previously reported, was in excellent condition when we commenced work on it.

RECORD OF SIX ACRES

Year	Approximate number of bushels produced	Approximate gross income	Approximate gross income per acre
1909.....	629	\$ 606.85	\$101.14
1910.....	1,900	1,900.00	316.67
Average result per year for 2 years	1,264.5	\$1,253.43	\$208.90

Much of the produce of this orchard has been used for exhibition purposes at State and County fairs and apple shows, and the figures given represent the income that would have been realized had the entire product been sold at the prices that were received for the fraction of the crop that was marketed. The crop for 1909 was 545.6 bushels of picked fruit and 83.4 bushels of drops. The No. 1 apples brought \$1.25 per bushel and the No. 2's brought 75 cents. As nearly as can be determined, the results given represent the income if the orchard had been handled as a purely commercial proposition. The quality and beauty of this fruit compared very favorably with the best that can be grown anywhere, as is well known by all who inspected the exhibit of the Experiment Station at the Ohio apple shows of the past two winters.

RECORD OF A FAMILY ORCHARD

A small family orchard near Wooster, belonging to Mr. A. A. Mowery, consisting of about 90 bearing trees upwards of 40 years old, and scattered over about 4 acres of ground, has done fairly well in spite of the fact that it had not been sprayed, trimmed, or given scarcely any attention for several years. The land in this orchard originally supported 40 trees per acre. The location is good. During both years in which we sprayed it, only one spraying was given after the bloom fell. Its record is as follows:

Year	Approximate number of bushels produced	Approximate gross income	Approximate gross income per acre
1909.....	877	\$845.00	\$211.25
1910.....	670	475.00	118.75
Average result per year for 2 years	773.5	\$660.00	\$165.00



Sound 3,895

Wormy 2,036

Sound 25 bushels

Wormy 21 percent

Wormy 5 bushels

Janet. Derthick orchard. No poison spray.

RECORD OF DERTHICK ORCHARD

Three other orchards have been under test for two years but none of these was in such shape at the beginning of the spraying as fairly to be regarded as representative Ohio orchards. One of 14 acres and more than 40 years old, located in northeastern Ohio, belonging to Mr. F. A. Derthick, Mantua, Ohio, had been defoliated for several successive seasons by canker worms and had not been sprayed or thoroughly trimmed for several years. Blight and collar-rot were very prevalent, and only 389 trees remained standing.



Sound 1,951

Wormy 66

Sound 9 bushels

Wormy 1-4 bushel

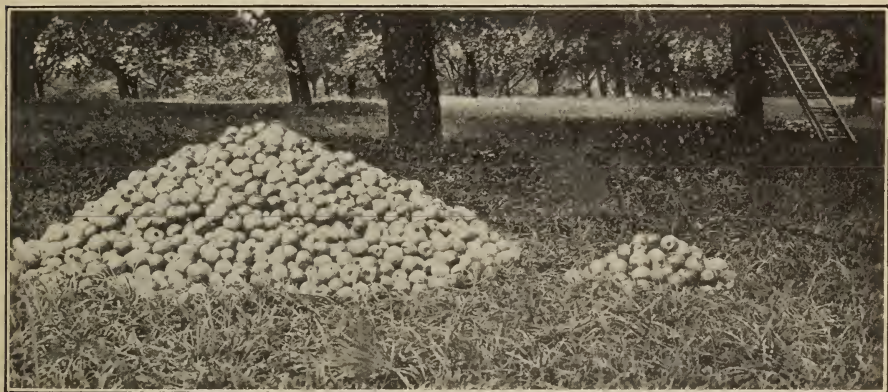
Wormy 3.27 percent

Janet. Derthick orchard. Two sprayings after bloom with Bordeaux and arsenate of lead, 3-3-6-50 formula

In the spring of 1909 the trees were banded with tree tanglefoot in March, and the females of both the fall and the spring species of canker worm were trapped in enormous numbers. Three bands, aggregating in width 12 to 15 inches, were required on some of the trees to stop the ascent. From 8 to 12 females per square inch were caught and, by computation, from 8,000 to 1,4000 of these were trapped on some of the worst infested trees. Notwithstanding these bands, a multitude of worms, apparently of the fall species, hatched and began feeding on the leaves as soon as they unfolded. A heavy spraying with arsenate of lead, before bloom, practically exterminated them, and the trees kept in fair foliage throughout the season.

The record for the two years is as follows:

Year	Approximate number of bushels produced	Approximate gross income	Approximate gross income per acre
1909.....	600	\$ 400.00	\$28.57
1910.....	1,450	1,000.00	71.57
Average result per year for 2 years.....	1.025	\$ 700.00	\$50.07



Sound 4011

Wormy 137

Wormy 3.3 percent

Sound 19 1-2 bushels

Wormy 5-8 bushel

Janet. Two sprayings after bloom with lime-sulfur, 1 gallon in 30 of water with 2 1-2 lbs. of arsenate of lead added to each 50 gallons.

For the year 1909 we have estimated the entire crop, both of No. 1's and No. 2's, as being worth 75 cents per bushel. In 1910, 450 barrels of fruit were sold at \$2.00 per barrel, the buyers furnishing the barrels. About 100 bushels were kept for home consumption and neighborhood sales, and something like 150 bushels of cider

apples were sold at 20 cents per bushel. The crop from this orchard was worthy of a better price. From 75 to 80 percent of the returns should be considered net. From any fair standpoint, the work of the past two years in this orchard should be considered rejuvenation work, as the orchard is just now sufficiently recovered from the effects of defoliation through several successive seasons to fairly show what it is worth and what such neglected orchards can become. Next year's crop ought to prove more representative.

ORCHARDS IN SOUTHEASTERN OHIO

An orchard of about 40 acres in Gallia County has been under test as a type of the hill orchards of southeastern Ohio. This orchard had not been sprayed for several years, and apparently owing to this and to the drouth of 1908, it was unable to hold its crop in 1909, only a small quantity being produced. The income was not enough to pay for the care of the orchard. Much work was done in trimming, cleaning out the briars, mulching it, etc. It was apparently in good condition to bear a crop in 1910, and a good return would in all likelihood have been obtained except for the freeze which came in May and destroyed every prospect in the orchard. Not a dozen apples were produced. An attempt was made to warm the air by burning heaps of brush trimmings which had been saved and piled for this purpose, but the high wind with driving rain and sleet put out the fires as fast as they were lighted. Whether or not any sort of orchard heaters would have proved of much value under such conditions is questionable, and the two years' record from this orchard must be written down as a failure.

Another orchard of 40 acres in Jackson county has a record quite similar to the last. In 1909 there was a small crop, enough to pay for the cost of maintenance and a very slender profit besides, but no crop at all was produced in 1910 because of the same freeze that destroyed the crop in the Gallia county orchard.

The Department of Horticulture is testing various systems of orchard heating and there is no apparent reason why these should not prove as successful and profitable in Ohio as they have done elsewhere. Before Ohio is on a level competing basis with other sections, her orchardists must learn how to overcome these frosts and freezes like their competitors have done.

RECOMMENDATIONS AS TO SPRAYING PROCEDURE

The conclusions regarding best spraying procedure, so far as agreed upon by the three Station Departments cooperating in these experiments, have been stated in Circular 109. The Department of Entomology, operating largely in the northern part of Ohio and working chiefly with varieties not specially susceptible to scab or

bitter rot, obtained very satisfactory results from the use of lime-sulfur solution as a summer spray and, for such conditions as prevailed in these orchards, we prefer this before any other mixture tried. No bad effects have been noticed from combining it with arsenate of lead, and it causes distinctly less russetting to fruit and less injury to foliage than any other spray we have tried.



Russeted fruit. Sprayed with Bordeaux. Ben Davis



Smooth fruit. Sprayed with dilute lime-sulfur. Ben Davis

However, severe russetting and cracking of fruit may follow the use of this combination, and variety is an important factor in determining the degree of damage, exactly as is the case with Bordeaux. Last year, in the Station variety orchard, trees standing in the same row and sprayed from the same tankful of mixture, only a few minutes

apart, exhibited all grades of russetting from perfect, unblemished fruit to apples as badly cracked as could be found in the plots sprayed with other mixtures. On the average, however, the amount of injury was insignificant as compared with that resulting from the use of the other sprays. There should be two sprayings before bloom, one with lime-sulfur solution, winter strength, before the leaves appear, to destroy scale insects and the hibernating forms of many other species; and another with weak Bordeaux mixture or its equivalent after the leaves are unfolded and just as the bloom begins to show pink. If aphids are abundant at this time use lime-sulfur solution diluted with 30 parts of water instead of Bordeaux for this application. As soon as the bloom has fallen, spray heavily with lime-sulfur solution and arsenate of lead. We use the commercial lime-sulfur solution, testing about 33 degrees Beaume, diluted with 30 to 40 parts of water and two pounds of arsenate of lead is used in each 50 gallons of spray. The effect of this spray throughout the summer on plant lice and scale insects is excellent.



Russeted fruit. Sprayed with Bordeaux. Baldwin



Smooth fruit. Sprayed with lime-sulfur. Baldwin

Some of the deformities on apples are due to injury initiated by plant lice, especially the wooly louse, and these malformed fruits were comparatively scarce in the plots sprayed with the lime-sulfur as summer practice. A second spraying with lime-sulfur and arsenate of lead combined should be given about ten days after the falling of the bloom, or it may be given about the middle of July to forestall the second brood of worms. We find practically no difference in the percentage of wormy apples at harvest time in case of the two sprays following close after the bloom, or one of them being deferred till July or early August. If these sprayings are properly made, from 95 to 99 percent of the apples will be free from worms at harvest time. This statement is supported by all the tests tried except the one in the Experiment Station variety orchard. Owing to the unevenness in the time of blooming in this orchard, thus compelling us to work on the best average date of development, thereby anticipating the best spraying date for a few varieties and passing it too long for most, we were never able to avoid from 5 to 25 percent of wormy fruit, with an average of 10 to 15 percent, notwithstanding the most thorough treatment.

We still follow substantially the same methods of application described in Bulletin 191 and Circular 95. We prefer a high pressure, from 150 to 200 lbs., to expedite work and insure thoroughness of application but have obtained almost equally good results with 80 to 100 pounds pressure by remaining enough longer with each tree to more than equalize the amount of liquid used.

Thus far we have preferred the large disc types of nozzles or else something approaching the vermorel clusters, such as a spramotor ring cluster of about six nozzles, rather than the Bordeaux types which give more or less of a straight, driving, stream spray. We think we can work faster with the former, secure a more uniform distribution of the fungicide over the foliage with less waste of liquid, apparently cause less damage to the tender skin of the young fruit from impact of the caustic spray against it, thus getting less of russetting, and at the same time get a sufficiently high percentage of sound fruit to be satisfactory.

It has seemed desirable to summarize at this time these quantitative results and main conclusions regarding procedure, without going into full details regarding the entomological data accumulated.

The entire assistant staff of the Department of Entomology have for the past four years been identified with this work, each assistant supervising the work in one or more orchards. The illustrations used in this Circular and the explanatory details accompanying them have been furnished by Mr. W. H. Goodwin.

Oh 3a
Safe

Ohio Agricultural Experiment Station

CIRCULAR No. 113

WOOSTER, OHIO, JUNE 30, 1911

ALFALFA IN OHIO—A FIELD STUDY



SIR:—I have the honor to transmit herewith and to recommend for publication as a Circular by the Experiment Station the accompanying manuscript entitled "Alfalfa in Ohio."

This paper, which has been prepared by Mr. W. M. Cook of this Department, is a progress report of a somewhat extensive field study of the alfalfa crop of Ohio. Of late years much discussion has been indulged in regarding the possibility of growing alfalfa in the various sections of this state and the best method to be used in doing so. After studying the alfalfa crop on almost 300 well distributed farms, it seems to be evident that this difference of opinion is due quite largely to the different conditions different persons have in mind. Methods which are best for one section are not necessarily suited to another. On some soils alfalfa is sown successfully in the wheat or oats just as the red clovers are seeded, while on others very much more care and expense are necessary to avoid failure. It is well for each prospective grower to study carefully his own soil conditions before seeding largely to this crop.

This report is offered as a contribution to the Agricultural Survey of the State which is being undertaken by this Department.

Respectfully submitted,

L. H. GODDARD,

Chief, Department of Cooperation.

Approved:

CHAS. E. THORNE, *Director.*

ALFALFA IN OHIO—A FIELD STUDY

By W. M. COOK

INTRODUCTION

Few if any of the numerous publications regarding alfalfa treat the subject exclusively from the viewpoint of personal field investigations of the work done by the farmers themselves. Such a study in the fields of Ohio growers has been conducted within the past year by the Ohio Experiment Station. In this investigation 293 farmers, well distributed over the state, have been visited (See Fig. 1). The observations of the year's work would indicate the need of a report of progress in which the successful methods of farmers in various sections of the state, with numerous differences, may be called to the attention of those interested.

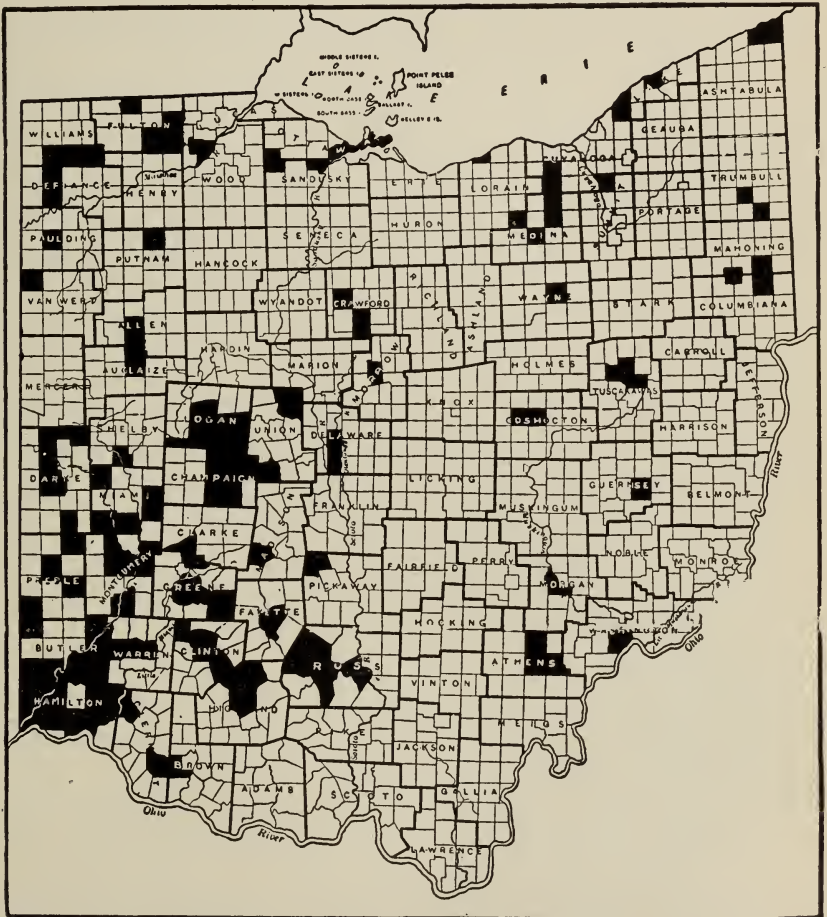


Fig. 1. Map showing townships visited in the alfalfa field investigation during 1910, when 293 farm visits were made in 49 counties of the state.

Acreage. The latest statistical report of alfalfa in Ohio shows the area of 1969 to be 21,794 acres, which is distributed among all the counties of the state excepting two. The official yield of the same year is 49,796 tons or a fraction over two tons per acre. Hamilton county leads in the number of acres grown, with Logan and Montgomery counties, in the order named, only a little behind. The high price of seed during the past few years may in part account for the slow increase of acreage in a number of other counties in which more recent centers of alfalfa production have been formed and which are evidently as well adapted to the crop as the counties containing the older centers where it has been extensively grown for a number of years (see Figure 2).

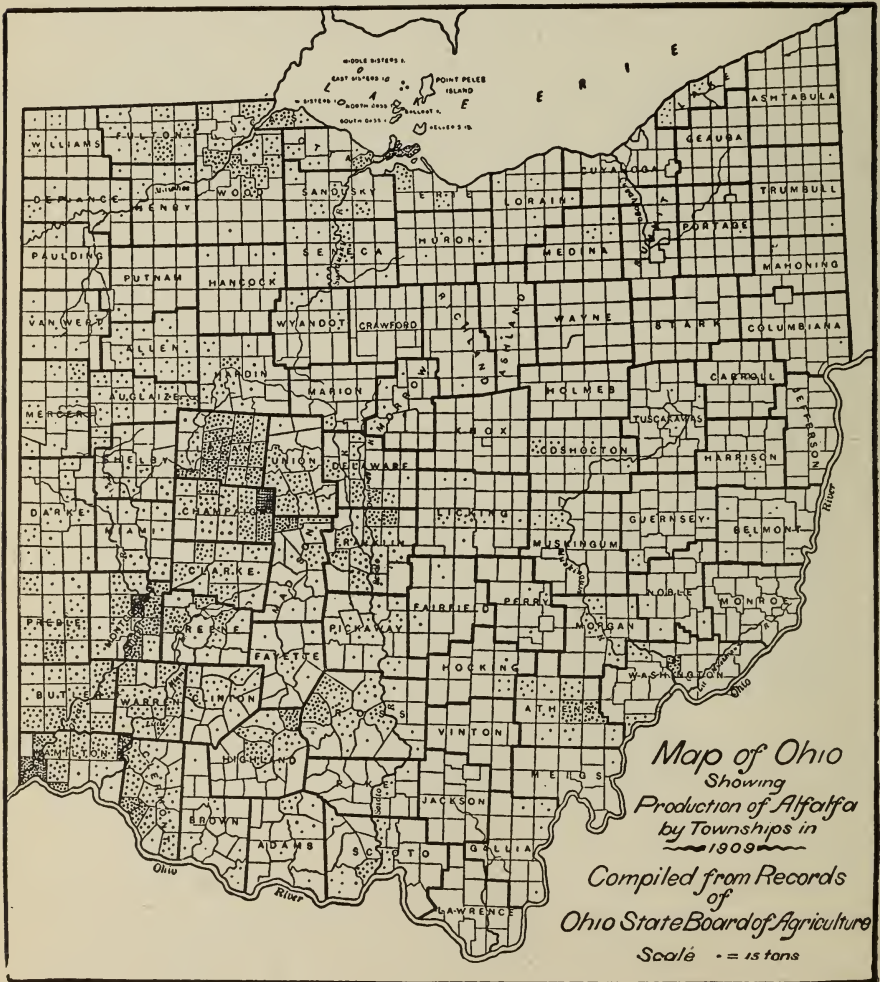


Figure 2. From Circular 100, Ohio Agricultural Experiment Station.

Alfalfa not a new crop in Ohio. It has been the prevailing opinion of late years that alfalfa is a recent introduction into Ohio, and in fact, quite recently, vigorous discussions have been conducted relative to its ever becoming a practical crop far north of Columbus. All this time certain farmers were quietly working out the soil's answer to this question. The oldest field of alfalfa located during this investigation is situated in Lake county, in latitude north of Cleveland. It has stood nineteen years without other attention than at harvest time. The ease of seeding alfalfa in northern Ohio counties where soil conditions are favorable is evident on certain farms in both Fulton and Sandusky counties, where it is seeded in the spring with wheat or oats with as much assurance of a stand as there is with red clover. One field in particular, near Delta in Fulton county, is worthy of mention. The sheaves of oats were green with alfalfa tops which were cut with the binder in harvesting the oat crop. The field was visited again later in the season when a good crop of alfalfa was ready for harvest. A Hamilton county farmer reports an alfalfa field which he often passed 46 years ago, situated along Little Duck Creek, in what is now a part of Madisonville. In Ross county near Greenfield there is a very small patch of alfalfa in a cemetery that was seeded in 1865 with seed brought from Germany. It is therefore quite evident that alfalfa is not a new crop in various parts of the State.

Peculiar requirements of alfalfa. A season's travel throughout the various agricultural sections of the State of Ohio cannot fail to impress one with the characteristic differences of soil problems in their relation to crops produced and methods involved. This fact is probably more particularly true in studying alfalfa, which is more exacting in many of its requirements than are other farm crops grown generally over the State. Differences of latitude, on the other hand, apparently have little to do with the location of the alfalfa centers. The variations of alfalfa yield in different fields apparently have a wider range than the general farm crops, due largely to soil conditions. This more delicate requirement of alfalfa is commonly believed to be due to the greater amount of certain kinds of plant food contained in a given amount of its hay as compared with that of a number of other grasses. However, this does not appear to explain fully the peculiar requirements of alfalfa. Sweet clover (*melilotus alba*) for instance, has about the same analysis as alfalfa, yet is found growing as a weed in parts of the State where alfalfa is grown with difficulty. This same difference between quite similar varieties of plants is further illustrated in the more general adaptability of Canada Blue Grass to soils upon which Kentucky Blue Grass cannot be successfully grown.

LIME, DRAINAGE AND OTHER FACTORS

Importance of lime. The location of the alfalfa fields of the State is to a certain extent a reliable guide to a number of soil characteristics, regarding which this crop is more sensitive than the general crops of the farm. The more important of these are lime and drainage. In addition thereto many local peculiarities exist which are more or less perplexing, although reasonably expected in a new crop upon which observations have not been extensive. The maps in this Circular showing the location of the limestone areas of the State (Fig. 3), as well as the limits of the glacial drift and old Maumee lake bed (Fig. 4), when studied in connection with the crops of the State give evidence of the necessity of considering the lime supply in growing the regular farm crops, and especially so in growing alfalfa, which contains 42 pounds of lime in a single ton of hay, or more than six times as much as is found in one ton of timothy.*

Original lime supply. The underlying limestone is of agricultural value in the various sections of the State where it comes near the surface. This is particularly true of the hills of southwestern Ohio. Along the lake shore and in Ottawa county, especially, this underlying limestone is of practical value for alfalfa growing. However, the limestone of the lake region does not offer the ideal condition for alfalfa unless overlaid with more soil than is necessary for the same crop on the limestone of southern Ohio. One reason for this difference is the character and position of the strata, which in the lake region are large and solid with compact seams, while in southern Ohio among the hills they are more broken and less compactly arranged, thus giving more opportunity for the plant roots to penetrate to sufficient depth.

Coal measure limestone. It is not uncommon in the coal measure areas of the State, as shown in Figure 3, to find an abundance of limestone outcrop on a certain level when both below and above that level there is a deficiency. This is well illustrated in the hills of eastern Ohio, back from the river, where the limestone is found with certain strata of coal outcropping on the highest hills with an evident shortage of lime in the fields lower than this level. Valley soils which have been formed by stream action are frequently well supplied with lime which has evidently been washed from higher hills, that by the process of ages of washing have been largely leveled below the original outcropping limestone formation. In many of the counties classed in the State Geological Report as having limestone both in and out of the coal measures, this formation is located at such a depth that plant roots are unable to reach it.

*Ohio Experiment Station analyses.

There are also small areas where the limestone originally came to the surface and has been disintegrated by continuous weathering to a pure limestone soil. Such a soil is not only valuable for alfalfa, but is probably among the best of the State for general farming.

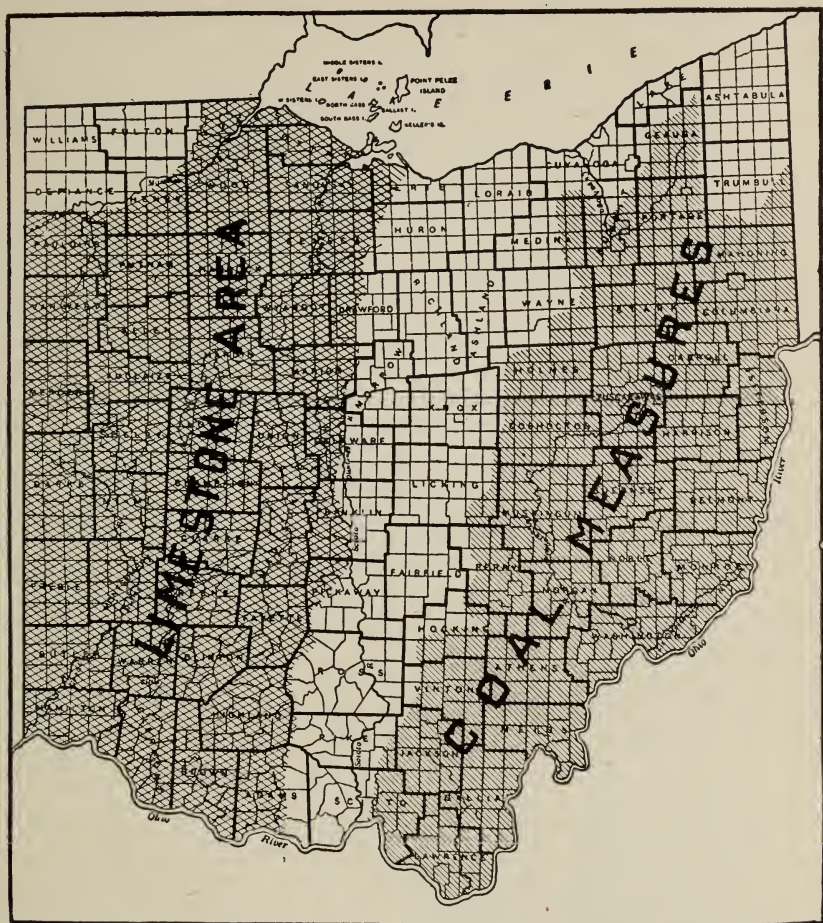


Fig. 3. Map of Ohio showing limestone area, and coal measure area in which limestone frequently appears.

Glacial lime supply. The limestone soils due to glacial action do not occur to a large degree in the eastern part of the State, whereas in the western part numerous areas were thus prepared for ideal alfalfa fields (see Fig. 4). The glacial drift is an important factor in soil conditions of the part of the State over which the glacier passed. The large body of glacial ice which carried northern soils into Ohio and mixed them with the material which it

ground up within that state, deposited a soil rich in limestone throughout much of the area over which it moved, although in the north-eastern part of the State this deposit is of a very different character and seldom contains an abundance of lime. However, limestone material was frequently carried into the freestone areas of the State. In Crawford county acres of limestone gravel have been deposited evidently by glacial action, within a few rods of and possibly joining in places, a sandstone quarry. It is quite evident that under such conditions limestone may be both plentiful and lacking in parts of the same field.

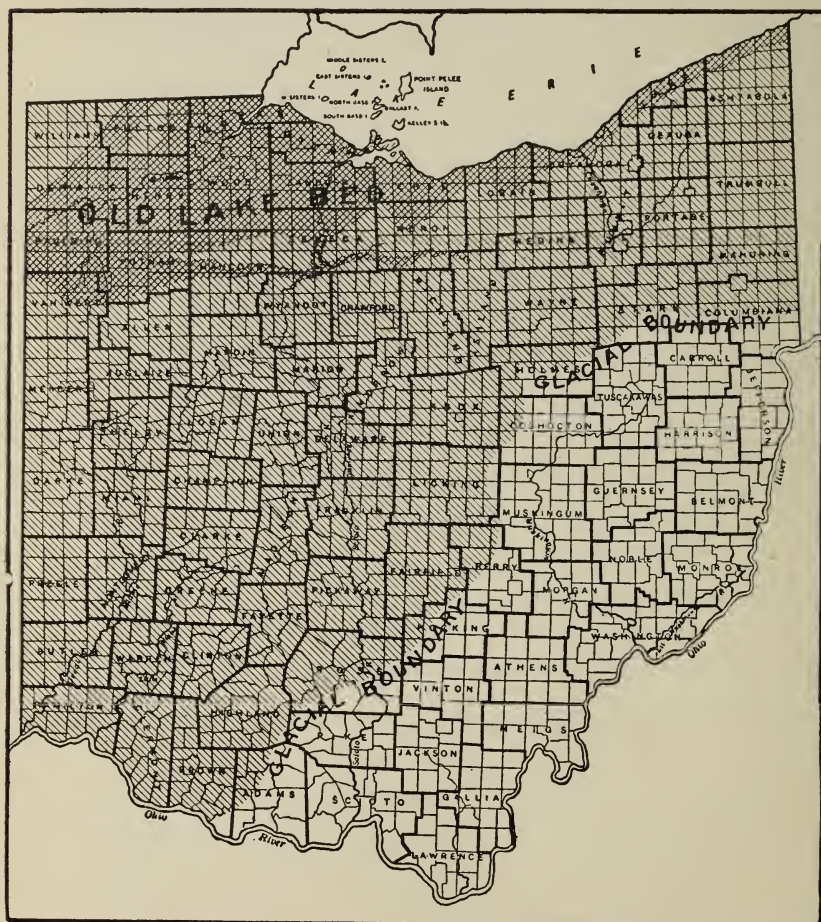


Fig. 4. Map of Ohio showing glacial area and old Maumee Lake bed.

Old lake bed. Large deposits of valuable lime have been made by the action of the old Maumee Lake which formerly covered an extensive area in north-western Ohio. The bed of this old lake extends as far south as the center of Van Wert county, where its shore is yet visibly marked by a gravel ridge extending across the country in a more or less irregular line in the general direction of Cleveland. A large portion of the State north of this line is included in this area, many parts of which are remarkably rich in lime from the animal life that existed in the lake. The northern boundary line is plainly evident by the difference of soil where it passes through Bryan, the county seat of Williams county. The farmers locally speak of the different character of the soil on opposite sides of this line; the soil generally being considered more productive on the south side. A long and very narrow neck of this lake bed extends east from Hancock county nearly to the south-west corner of Medina county. The location of the southern limit of the lake bed through the eastern part of the State is only a few miles south of the present lake shore. Here it is known locally as "South Ridge". Indian trails formerly followed this gravel ridge in various places and at present wagon roads are constructed along it in a number of counties. During the period of this enlargement of Lake Erie there was an outlet which drained it in a south-westerly direction, extending across the State of Indiana near the present site of Ft. Wayne. The lime deposits which are unquestionably due to the lake that once covered this extensive area are not generally observed, although during the time spent traveling through this section a number of interesting examples were located. Enough were seen to make it quite evident that numbers of areas exist in this part of the State which are well adapted for alfalfa.

Marl. In addition to the more extensive supplies of lime referred to, local deposits of marl rich in lime are found in a number of counties. However, owing to the depth below the surface and the small area of such deposits, their direct supply of lime to the alfalfa fields is not extensive. In a few instances, where such deposits are near streams, the evidence of lime is apparent farther down, indicating that by stream action it has been carried there. Such an effect could be detected only where lime was otherwise deficient. Such deposits were found in Morrow, Lake and Huron counties.

Underlying limestone frequent in western Ohio. The effect of an underlying limestone formation is in evidence over a large part of western Ohio. It is especially marked in Hamilton county,

where alfalfa is grown with little trouble on the stony hillsides. Many of these hills which are so stony that cultivation is next to impossible, grow alfalfa luxuriantly. Several other limited areas in the State have soils of a similar formation to which alfalfa is equally well adapted.

Glacial limestone supply in freestone areas carried by stream action. On the Experiment Station test farm in Cuyahoga county the clay is very tenacious and very deficient in lime, which is also true of the county in general. Near this farm, at Berea, are extensive sandstone quarries covering hundreds of acres, yet less than a mile from Berea up the valley of Rocky River, which flows through the village, is a fine field of alfalfa, indicating an abundance of lime. The natural stone of the stream was examined and no trace of limestone could be found. Neither could the abundant supply of lime be accounted for in any other way at the time the field was visited. Some time afterward, however, while visiting a farmer more than 50 miles away this circumstance was related to him and the whole matter explained by his statement that his grandfather formerly owned a farm some distance above Berea, near this same stream, on which he had burned limestone gathered from his fields. In this case glacial action had evidently deposited a local supply of limestone boulders, which had slowly broken down and become a part of the overflow soil farther down the valley.

Stratified limestone supply in non-glaciated areas carried by stream action. In the valley of the Walhonding river, in Coshocton county, is another example of stream action affecting the lime supply. In this instance stratified limestone which formerly lay in the tops of the highest hills has been disintegrated and turned into soil. A rich valley with an abundance of lime upon which luxuriant alfalfa grows, is the result. Only an occasional hill top yet retains the original outcrop of limestone which is now being applied to many of the hill fields for best results in growing the common field crops of the section. Near Warsaw, in this valley, is an example of an overflow field growing alfalfa for fifteen years, the field containing an abundance of gravel from the previously mentioned limestone. The owner of a near-by farm was recently offered fifty dollars for the limestone on one such hill to be used upon the neighboring fields which are deficient in lime. Alfalfa has been grown for at least fifteen years in the Walhonding valley with marked success. One overflow field produced good alfalfa crops for eleven years, after which it was plowed in order to break the bluegrass sod that had formed and was immediately reseeded with success. The average yield per acre of hay for this entire period was about four tons per season.

Hydrochloric acid treatment. Various soils in this valley and elsewhere were treated with a dilute solution of hydrochloric acid and found to contain enough lime to cause an immediate effervescence. Upon most soils this acid solution produces no different appearance from that which as much water would cause, but where enough lime is present the action is similar to water boiling in the soil. A small bottle of this acid, diluted with four parts of water to one of acid, was carried for this use during the study. When desired a small portion of this liquid was poured upon samples of the soil as removed from the earth at various depths, or it was often poured upon the surface of the soil. Many successful alfalfa fields visited were not rich enough in lime within a depth of three feet to show any effervescence when treated with this hydrochloric acid, although every alfalfa field rich enough in lime to respond to this treatment was producing profitable crops. This was found true on alfalfa fields in various sections of the State and with different soil conditions. However, it must not be inferred that the other essentials for successful alfalfa culture were lacking in any case.

Litmus paper test. The litmus paper test is apparently of little value in determining the soil requirements for alfalfa. This test does not determine the amount of lime in the soil but merely indicates on which side of the neutral point a particular soil may be. A very small amount of lime might be applied to certain soils and cause the soil to show a favorable litmus test reaction. Such a condition, which might possibly suit some of the farm crops, would not meet the requirements of alfalfa, which demands several times the amount of lime used by some of the other crops. It is true, however, that in a large number of cases over the State alfalfa is successfully growing on soil not sufficiently supplied with lime to show any reaction when treated with hydrochloric acid. Therefore, it is not to be concluded that the hydrochloric acid test will detect the alfalfa soil, but it appears evident that where soil is found to react, that soil may with some degree of certainty be expected to grow alfalfa profitably, providing it is properly treated otherwise.

Soil auger. Throughout this investigation a soil auger was carried, with which soils were easily sampled to a depth of 30 inches. The auger used was a $1\frac{1}{4}$ inch wood auger, with the gimlet point removed, and the auger extended as shown in Figure 5.

Glacial limestone in freestone areas not moved by stream action. In Morrow county is an example of a locality in which fine alfalfa is grown upon upland soil containing no stratified limestone according to the State reports. A fine field of alfalfa has been giving three crops each season for the past seven years near the village

of Edison in this county. The gravelly hill portion of this field was treated with hydrochloric acid and showed a marked reaction. The more level portion of the field upon which the alfalfa was not so good showed no effect from the acid. A good stand remained over the entire field after having been seeded eight years, yet the hill portion grew the more luxuriant hay crops. Glacial action has probably been the cause of this local supply of limestone gravel. It is barely possible, however, that a bed of marl which was noted in that county may have had something to do with the lime in the soil of the lower ground.



Fig. 5. Sectional soil auger used in sampling soils of alfalfa fields.

Old lake bed field growing four crops of alfalfa. In southern Williams county there is a field which yielded four crops of alfalfa this past season (see Fig. 6). Numerous shells are found as deep as three feet in the soil of this vicinity, which were doubtless deposited there by lake action. The available supply of lime associated with the other essentials in this field produces ideal conditions for profitable alfalfa growing. Frequent gravel banks are found in this lake bed area, some of which cover acres. A few artesian wells were located, indicating a uniform water table during the entire year. The quick drainage through a gravelly limestone soil in this case is very similar to parts of both Preble and Champaign counties having artesian wells and also especially adapted for alfalfa.

Old lake bed sand growing profitable alfalfa. It may be well to mention another phenomenal success which is situated in the same lake bed, but in Fulton county near the Michigan state line. The soil in this case, which in places is yellow sand to great depth, is probably entirely different from anything that will be found elsewhere in the State. The soil of this field is pure sand to a depth of at least 20 feet. This sand is so light that a winter cover crop is required to keep it from blowing into ridges. Alfalfa is profitably grown upon this and other fields of like nature in this vicinity. Previous to the growing of alfalfa upon this farm the owner had desired to sell and, being unable to find a

buyer, offered it at public auction but failed to secure the first bid. Seven years ago an old orchard on this farm was seeded to alfalfa which is yet standing. It was cut for hay until other grass came in with it to such an extent that it is now being pastured with hogs. Although this soil does not produce a sod easily, a satisfactory one is forming of itself in the seven-year-old alfalfa.



Fig. 6. Fourth crop of alfalfa already harvested, October 26th, in the northwest corner of Ohio. This soil contains numerous limestone deposits to a depth of three feet, due to the old Maumee Lake once covering this part of the state.

Sands vary in lime supply. So far as observations were made the lake bed sand is apparently richer in lime and better adapted to alfalfa growing than sand found along the streams of the State. Observations in Cuyahoga, Allen and Shelby counties lead to the conclusion that alfalfa is not profitable in the sands of some of the streams passing through them. The lake bed condition was evidently more favorable for the preservation of the lime than the stream systems which tend to wash any soluble material farther down the water course.

Lime supply often more abundant in sub-soil. Several instances have been observed where alfalfa was better in dead or finishing furrows than in the remainder of the field, indicating among other things more abundant lime supply in the sub-soil than near the surface. Also it is noticed that the sub-soil remaining on the surface after filling a tile drain often marks a much larger growth of alfalfa, while other fields which were equally in need of drainage do not show this difference. It is quite evident that one soil may be more deficient in lime near the surface while another

may be as well supplied at the surface as in the subsoil. It is frequently found, however, that the sub-soil at a depth of two or three feet contains enough lime to react from the hydrochloric acid treatment while the surface soil may not so respond. In one particular case in Ross county in a field seeded to alfalfa, no action was to be seen when the acid was applied to the soil from as great a depth as could be reached with the soil auger, whereas there was a noticable effect when dirt excavated from the depth of six feet was given the same treatment. Several acres of this soil have been growing alfalfa successfully from the original seeding, which was made fifteen years ago. Four crops per year are usually harvested from this field and sold on the market (see Fig. 7).



Fig. 7. Fourth crop of alfalfa from an 8-acre field at Chillicothe belonging to a cemetery seeded 15 years ago, with no later expense except harvesting and selling the hay crop, which the past season found a ready market at \$15 per ton direct from the field.

Application of lime upon field with sub-soil rich in limestone. The effect of an application of lime upon a new seeding of alfalfa in Seneca county was marked during the first season but could not be observed the second one. This was not due to the apparent reason of the applied lime having been exhausted the first season, as will be evidenced by the fact that both limed and unlimed portions were improved the second season. The owner was no doubt correct in concluding that the surface soil in which the alfalfa roots grew the first season was deficient in lime and that for this reason the application of lime was beneficial the first season; but as the roots grew deeper the second season they reached down to where there was abundance of lime so that the applied lime was of no value to the deeper-rooted plants. The same condition exists in parts of Hamilton county where alfalfa fields from which the lime has been

exhausted from the surface soil are underlaid with an abundance of limestone in the subsoil. In this soil the alfalfa starts poorly the first season while the roots are small and near the surface, but a marked improvement takes place the second season when the roots have reached the rich, limestone soil. A number of local instances of peculiar lime supply and its effect upon alfalfa have been observed. One such example is on a limestone soil in Allen county fairly well adapted to alfalfa, which showed the more luxuriant growth of alfalfa where the Trenton limestone from an old oilwell had been deposited upon the surface soil (see Fig. 8).



Fig. 8. Trenton limestone deposited from an old oilwell on limestone soil in Allen county, showing a much more luxuriant growth of alfalfa on the right than on the remainder of the field.

Sources of lime supply. From the foregoing it will be evident that success with alfalfa, so far as lime is concerned, depends, in the limestone areas of Ohio, upon one or all of three natural conditions: (1) nearness of original limestone to the surface; (2) glacial action; (3) stream action. In the freestone areas it depends upon (1) glacial action, (2) stream action. The old Maumee Lake bed, as shown in Figure 4, is another source of lime supply contributing quite largely to the success of alfalfa in a number of counties throughout northern Ohio. Marl is of benefit in a limited area.

Drainage. The problem of drainage in Ohio is as local as that of lime supply; however, in numerous cases there is an association between the two. The gravelly and sandy soils of the State are as a rule well drained, although in some such soils it is necessary to tile-drain in order to lower the water table sufficiently for the alfalfa to stand. The stony soils are usually perfectly drained, and in case

they were not, artificial drainage would not be practical. In many cases the stone, gravel and sand are limestone or of limestone origin. The remaining soils of the State vary from quickly self-draining soils to those which are so tenacious that water will stand over the tile for a considerable time. Localities in both Mahoning and Putnam counties were visited where the clay is so tenacious that farmers report that it is of little use to tile-drain unless the ditches are filled with a more quickly draining material than the clay itself. Cinders have been found practical for this purpose where available and have been used to advantage in both of the counties named. Still another condition is reported in Clermont county, where in certain localities a very fine, dark-colored sand is carried by the drainage water through the joints of the tile, to such an extent that it has been known to fill the drain so that the water is unable to pass through.



Fig. 9. Photograph of a Shelby county alfalfa field showing the smaller alfalfa growth upon unbroken clay at least 30 inches in depth (under wagon), compared with the same soil having a 2-inch layer of sand at a depth of 18 inches (where man stands).

Differences due to lime and drainage. Probably no better example of soil variation and its effect upon alfalfa growth could be found in Ohio than in a field visited in Shelby county, where four degrees of success are attained with a distinctly different character of soil underlying each. The use of the soil auger showed the best alfalfa in this field to be growing over a limestone gravel pit, bordering which is the poorest alfalfa over a sand pit. The remainder of the field is a stiff clay soil, part of which is solid clay to the depth of the soil auger. On this clay soil the alfalfa grows a little better

than over the sand. Scattered through this clay portion of the field there are spots where the alfalfa is nearly as fine as over the gravel pit. In such places the soil auger revealed a 2-inch layer of sand at a depth of about 18 inches. The difference in growth was so marked that the effect of the two inches of sand is easily detected in Fig. 9 where the taller alfalfa, growing under this condition, is compared side by side with that growing over the clay sub-soil without the layer of sand.

The striking differences in this field are largely due to lime and drainage, with the possibility of deficient plant food in the sand pit. The important point in practice is cause and effect rather than any supposition relative to the theory of the matter, and just to what extent each is a controlling factor in the results upon the four soils described is of less importance than to know that both lime and drainage are essential to success. In this instance it is quite probable that both glacial and stream action contributed to the soil differences. Drainage is none the less essential because lime is in abundance. This point is well illustrated in Ross county in a field responding readily to the acid treatment, but which required from forty to sixty rods of tile drain per acre in order to keep the plants alive during the freezing and thawing of early winter and spring.

This particular soil is a very tenacious clay, through which it was difficult to penetrate with the soil auger while sampling the soil. The field was satisfactorily ditched for the regular farm crops previous to the growing of alfalfa, but additional draining was required for the growing of this crop (see Fig. 10).

In this instance it was found that the only way to locate accurately the needed drains was to examine the alfalfa and run the ditches through the injured portion of the field in the winter or early spring during the period of greatest moisture. The resulting benefit to the alfalfa crop was considered many times that of the injury done to it in placing the tile through the growing crop. Four fine crops have been harvested the past season, yet more tiles have been placed in readiness with the expectation that another spring will reveal other spots that may be improved by passing a tile drain through them. Few upland soils in Ohio containing an abundance of lime present a more adverse situation under which to secure a stand of alfalfa than the foregoing example in Ross county.

While this is true of stiff clay soils, it is just as evident that other soils lack this retentive quality to such an extent that sufficient moisture is lacking during the dry summer season. Such a field is situated upon the Chagrin River in Lake county. Portions

of this field support a luxuriant growth of alfalfa while spots with the same surface soil make a much smaller growth, this being the more noticeable as the season advances. On examining these spots to a depth of three feet it was observed that while there was sufficient moisture in the sub-soil under the best alfalfa to cause the auger to retain the soil when it was withdrawn from the ground, under the poor spots the soil fell loosely from the auger, apparently containing no moisture whatever. Otherwise the appearance of the sub-soil in each instance was very similar, thus showing that the lack of growth was doubtless due to the sub-soil water escaping unduly.



Fig. 10 Tile drain located after the alfalfa was seeded, and placed where the crop was injured the following spring during wet weather. Notice the narrow strip of alfalfa injured by placing the tile drain.

Surface drainage. On the more tenacious soils it is the opinion of alfalfa growers that surface drainage is of considerable value in more quickly removing the water, though the field may be reasonably well under-drained. Under certain conditions water may cover an alfalfa field for several days without harm, while on the other hand a short period of inundation often results in injury to the crop. Overflow river bottoms are often inundated and a sediment of as much as two or three inches deposited on the alfalfa without injury providing it occurs during winter or early spring. After such an overflow it has frequently been necessary to disc the soil thoroughly to break the crust before the spring growth of alfalfa could start. It has frequently happened that a sudden freeze before the water has been removed from the surface results in a thin sheet of ice forming over the alfalfa and working considerable injury. This may readily occur over tile-drained fields from which the water drains slowly.

Water table. The prevailing opinion among both writers and growers that alfalfa requires a low water table is not found to be correct in all instances. It would appear that a much more important consideration is that the water table be comparatively stationary; that in case of a high water table the water remain at that high level during the whole season. The plant must have water and air and the peculiar tendency of alfalfa is to grow deep to find the moisture needed. If after reaching this depth the water table is suddenly raised for a considerable time the air will be cut off from the roots below that level so that they cannot thrive. It will be manifest, however, that if the water remains within a few feet of the surface during the dry season the roots will never reach the greater depth and greater supply of plant food that they will in other soils. A striking example of this is located in Logan county on a farm situated along a small creek. Artesian wells are constantly flowing in several places upon this farm, and previous to tile draining the water always stood on the surface of the valley fields. Tile drains have been placed at a depth of about thirty inches in order to lower the water table. Crawfish continue to work in this soil the same as before tiling. At any time during the year a pebble dropped into one of these holes may be heard striking water on a level with the tile drain.

An example of a rotation with water table three feet below surface. Alfalfa is very easily seeded in this soil and is being used in rotation with potatoes quite successfully. The system is extremely flexible, as the alfalfa will stand any number of years desired, after which it is plowed down and the field planted to potatoes. The crops following alfalfa outyield those in any other cropping systems tried upon this particular farm. The weed problem, which is so troublesome in rich bottom fields, is greatly reduced by the alfalfa, which starts early in the spring and is harvested three or four times each season. The potatoes following such a crop are much more easily cultivated. When it is desired to seed alfalfa again the potatoes are planted early and dug in time to sow the alfalfa the same season.

Natural drainage. Quite a large percent of the alfalfa grown in Ohio is in soil having natural drainage through gravel or rock. This is particularly true in large areas of the older centers of production like Hamilton county, containing an abundance of stratified yet disintegrating limestone, and Logan and Champaign counties, which have large areas of gravelly soil giving perfect drainage.

Injury to tile drains. Reliable information regarding the injury of alfalfa roots to tile drains is not easily secured. Only one instance has been positively reported in which the roots actually

filled a tile drain. This instance was in Sandusky county, where a field of alfalfa had stood for seven years over a three-inch tile drain placed at a depth of about three feet. Thirty rods of this drain were taken up and the tiles were found full of a continuous mass of fibrous roots. This farmer is of the opinion that a period of four years' growth would not form sufficient root system to injure the drains. In this field the tiles were only carrying water during the rainy periods of the year. This fact would no doubt be an important factor and under conditions of moisture that varied from this field in this respect the same trouble might not be experienced. The possibility of injury to tile drains should not be taken too seriously when numerous fields are growing alfalfa over tile drains with no apparent trouble. This instance was related to a farmer of Defiance county who suggested his own experience as possible evidence of there being a mistake as to the cause of the tile filling with roots. This farmer also took up a tile drain which was under an alfalfa sod and found it filled with plant roots which he attributed to the alfalfa until afterwards he found the same condition in an adjoining field in which there was no alfalfa. Anyone in doubt about injury from this cause can easily examine the tile drains before they are seriously injured and if necessary plow up the alfalfa. If true at all it is probably only with the most favorable surroundings for alfalfa that the stand will remain long enough for the roots to cause such injury. Under such favorable conditions the profits from four or five tons of hay annually from each acre will justify an occasional reseeding, or even the relaying of a few ditches should it become necessary.

Effect of streams. Not only are the valley soils of the larger streams of the State in many cases liberally supplied with lime but also their drainage is usually rapid and complete. The map showing the centers of alfalfa production in the state indicates a much larger acreage along the streams. (see Fig. 2). However, when alfalfa becomes better understood its area will doubtless be extended into sections which are not now considered to be suited to the crop. An observing alfalfa grower of Logan county remarked, "Years ago when we began growing alfalfa upon our farm we thought our best corn land would also be best for alfalfa, but in later years we have learned that our best success with alfalfa is on hillsides where corn is not so profitably grown." This soil is a gravelly clay with more limestone gravel upon the hills than on the lower and more level fields. He suggests that the hills have more tendency to dry out when the corn crop is most in need of moisture, while the alfalfa which roots deeply in this better drained limestone gravel soil may reach moisture at greater depth.

Southern hills favorable. The length of the season is considerably affected by the lay of the ground. On southern slopes it is longer than elsewhere. An alfalfa field facing the south at a steep angle was visited in Hamilton county. This field was in blossom before the middle of May and was ready for harvest a few days later. Numerous hills of a similar nature in that county are growing good alfalfa. However, at present the best is grown along the valleys of the larger streams.

CLIMATIC CONDITIONS AFFECTING ALFALFA

Latitude. A difference of more than 200 miles in latitude between Northern and Southern Ohio must result in considerable variation in alfalfa methods. While soil variations are probably by far the more important, the latitude can by no means be overlooked by those contemplating this crop. The question of a nurse crop may in part depend upon climate, as likewise method and time of seeding, all of which are considered elsewhere. The winters in northern Ohio are considerably colder than in the southern part of the State, and constant cold weather with a small amount of alternate freezing and thawing is expected. In the southern part, on the contrary, the soil more frequently thaws during the day and freezes again at night. It is not uncommon for snow to cover the ground during most of the winter in northern Ohio, while farther south the ground is more frequently bare. These are probably among the differences causing more uncertainty, during certain seasons at least in securing a stand of alfalfa farther south. It is therefore evident that even more attention may be required to promptness in removing the surplus water in the southern part of the State where the soil is doubtless subjected to a greater amount of alternate freezing and thawing than in the northern part. No information has been obtained that would lead to the conclusion that continued cold weather is injurious to alfalfa under the ordinary methods of handling the crop.

First hay crop often woody in southern Ohio. It is a common complaint among dairymen in Hamilton county that the first crop of alfalfa is of a coarse, woody nature, and that it is difficult to make a good quality of hay from it, but owing to the fact that few if any are certain of the source of the seed, it is difficult to know how much the variety might have to do with this condition. However, it is longer in maturing than the later crops, thus allowing more time for the stems to become tough and woody. In order to guard against this they find it necessary to cut this crop while less mature than is the practice with later cuttings. On this account as well as that of less favorable weather conditions than later, it is often

impossible to make a good quality of hay from the first crop unless field covers are provided for the hay during the process of curing. In alfalfa centers farther north this difficulty from woody hay is not experienced and there is no discrimination against the first crop by dairymen. The first crop is allowed to reach the same maturity as later crops without any injury to the hay. This brings the harvesting at a later date, which means a possibility of better weather conditions. The season, too, being considerably later farther north, also brings the first cutting at a later date.

Adaptation of Alfalfa to Ohio conditions. The alfalfa fields of Ohio indicate that geological formation and other local factors affecting the soil are more important to the successful growth of alfalfa than to that of the other general farm crops of the state. The shorter season of northern Ohio requires a smaller eared corn to mature, even though the soil may be better than in the south. The oat crop is evidently more profitable in northern Ohio, irrespective of soil conditions, as shown in the map of centers of oats production.* Alfalfa apparently differs in this respect, so that when other things are equal there is probably as much to be said in favor of alfalfa in either extreme of the state.

Besides the various differences of soil, drainage requirements, and climate, that are found in the different parts of the State, the same unexplainable requisites that are noticeable in alfalfa growing, for example, make two sections of equal soil fertility, in one instance excellent for corn while in another particularly adapted for potatoes. The physical condition of a soil may be improved in many cases by intelligent methods, yet the availability of plant food and the success with which various crops succeed, is found to be dependent not only upon the more commonly considered soil factors but also upon the varying capacity of different plants to utilize the plant food in the soil as well. This fact is evidently an important factor in locating the various crop centers* of the state. The value of soil analysis, which may express the entire amount of plant food, depends, so far as practice is concerned, upon its correlation with the growth of farm crops.

ALFALFA METHODS LOCALLY APPLIED

Viewpoint. The presentation of the subject to this point has been from the viewpoint of soil, drainage, climate, etc., in its relation to alfalfa as observed in the field investigation. It is now desired to continue the discussion of the same general question from the standpoint of the crop itself, in which it will be endeavored to present methods that in the actual experience of farmers contending with these various environments have best succeeded in different parts of the State.

*Circular 100, Ohio Experiment Station.

NURSE CROPS

One of the more frequent questions asked is regarding the nurse crop, and it is usually implied that the question is one that it is possible to answer once for the entire State, and indeed it is so answered by many growers who refer to their own local experience as proof. Such unwarranted conclusions have unfortunately misled many new growers into seeding a large acreage without actual knowledge of local conditions, besides deterring others from even attempting to grow the crop.

Purpose of nurse crop. Observations over the state would indicate the following regarding the nurse crop: (1) under the most favorable conditions in Ohio nurse crops of various kinds are grown for the additional profit they bring without injuring the alfalfa in any way; (2) under less favorable conditions nurse crops of various kinds are grown with no hope of added income from the crop but with the idea of its being less harmful and more easily controlled than weeds that would otherwise compete with the alfalfa; (3) under the least favorable conditions under which alfalfa is grown nurse crops result in injury and loss of the alfalfa. The larger part of the state must be classed under the last division. A number of counties will safely come in the second division while there are probably only limited localities that can be put in the first class.

When the nurse crop is profitable. Alfalfa fields have been visited in Allen, Athens, Coshocton and Fulton counties which were successfully seeded with oats and in exactly the same manner as red clover is commonly seeded. The yield of oats that was threshed from the field thus seeded in Allen county was sixty bushels per acre.

Oats in Fulton county. Oats harvest was in progress during the first visit to the Fulton county field and the sheaves of oats were green with the tops of the alfalfa plants cut off by the binder set at a moderate height. The oats were very heavy and slightly leaning in places, yet the stand of alfalfa was uniformly good over the entire field. The alfalfa tops in the oat sheaves were probably six inches long on an average. A later visit was made and the field was photographed showing a crop of alfalfa that could have been harvested profitably had the owner not desired to have it pass the winter uncut (see Fig. 11). Any one of the four fields mentioned in this and the preceding paragraph could have been cut for hay the first season had it been thought wise to do so.



Fig. 11. Field of alfalfa seeded among oats in Fulton county exactly as red clover is seeded throughout Ohio. Photographed in October the same season the oats were harvested, when a fair crop of hay was ready for the harvesting.

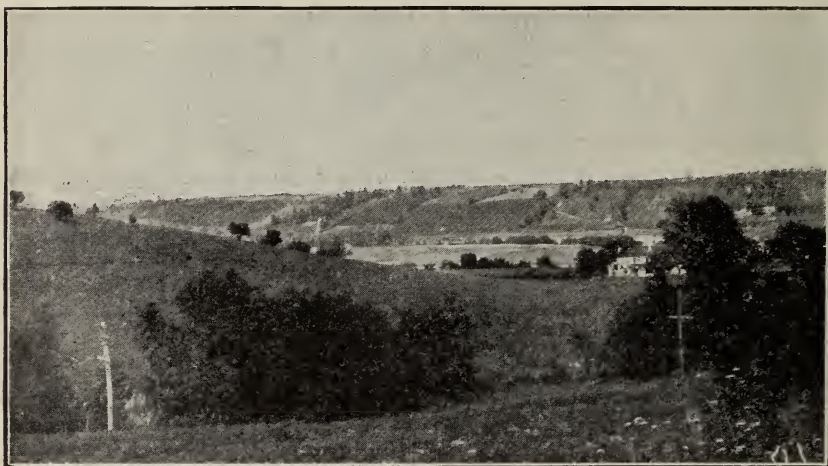


Fig. 12. Typical alfalfa fields easily seeded on the hills of the lower Miami River in Hamilton county. Erosion due to cultivation and neglect has permanently injured many of these limestone hills.

Wheat in Hamilton county. One successful grower on the banks of the Miami river in Hamilton county who seeds alfalfa in the wheat has found that the hill tops of his farm will start alfalfa readily but that before winter it will have perished, while on the hillsides and valley land it succeeds perfectly. His practice has been to seed lightly to wheat in the fall, then harrow the wheat with

a spike-tooth harrow about the first of April, when the alfalfa seed is sown, and possibly harrow again if the weather conditions will permit. The wheat is harvested in the usual way (see Fig. 12). Instances are also at hand in Hocking county in which alfalfa has been successfully seeded in wheat fields.*

Hay crop the first year. Some experienced growers, who find it possible to succeed according to the methods described, prefer to omit the wheat or oats and seed the alfalfa alone, bearing in mind about the same precautions they would consider wise in seeding red clover. Under the ideal soil conditions required for this method the larger amount of hay secured during the first season is often found equal in value to the nurse crop that otherwise could have been grown. However, the very small percent of farmers who have soil conditions so well adapted for alfalfa growing are probably in much less danger of following the wrong method than are those farming under more adverse conditions.

Barley as nurse crop. In the second place, and under less favorable environment, where the nurse crop is grown primarily for keeping down weeds, a number of grain crops have proven valuable in the estimation of Ohio growers. Spring barley probably has the best reputation and is used more or less wherever alfalfa is grown with a nurse crop. One advantage it is claimed to have over oats is the smaller number of blades, thus allowing more sunshine to reach the alfalfa. One trouble that is common in the use of all nurse crops is the sudden exposure of the small alfalfa plants to the direct rays of the sun, when the nurse crop is removed. In order to overcome this difficulty as much as possible it is a common practice to harvest the nurse crop before maturity. This is particularly true of oats, which ripen comparatively late. The nurse crop is usually seeded more lightly than would be done if it were not for the alfalfa.

Pasturing. In a number of localities growers have disposed of the nurse crop by pasturing with hogs. Although the majority of growers object to any form of pasturing, a number of favorable reports have been received regarding this method. One point in favor of this method of disposing of the nurse crop is that there is no sudden exposure of the young alfalfa plants to the rays of the sun during the hot, dry part of the season.

Rye. A number of growers report as successful quite a unique plan with alfalfa in which fall rye is seeded in the spring as a nurse crop. It is found that fall rye seeded in this way will make sufficient growth to keep back spring weeds and by about

*Circular 107, Ohio Experiment Station.

the middle of July the rye will begin to die. The advantage of this plan would appear to be in avoiding the sudden exposure of the young alfalfa plants to the sun as in the previous case of pasturing, and also in overcoming some of the objections to this pasturing method.

When the nurse crop is a robber. The third condition and that under which the nurse crop has proven a disadvantage represents the least favorable conditions under which alfalfa is grown in Ohio. The most frequent reason for alfalfa not growing is reported to be a lack of moisture. The same cause is also attributed to the increasing uncertainty in securing a stand of red clover, especially in southwestern Ohio. The particular localities where alfalfa cannot be grown easily with a nurse crop probably have the same rainfall and in some cases soils equally retentive of moisture, as those in which alfalfa grows most readily. It is therefore quite reasonable to suggest that where alfalfa grows less readily a lack of something in the soil besides water is the controlling factor. In soils more abundantly supplied with these elements though with no greater amount of soil water the plant is satisfactorily nourished. Coupling with this the fact that each ton of alfalfa hay contains 42 pounds of actual lime and also that many soils are lacking in lime even for the common farm crops which require a comparatively small amount of lime, a shortage of this substance would naturally be a controlling factor.

Alfalfa vs. red clover. Under the conditions last named, where lime must be supplied to the extent found necessary on the Experiment Station farm at Wooster, the experience of farmers in general supports the conclusions announced in Circular 91 of this Station, in which it is shown that at present alfalfa is no more profitable and possibly less so than is red clover when everything is considered.

VARIETIES OF ALFALFA

Acclimated seed. The growing of alfalfa has yet one particular obstacle in the way of its success in Ohio, if we are to take other farms crops as an example. Alfalfa is about the only one of our commonly grown crops from which seed is not profitably produced in Ohio, at least for seeding purposes. Alfalfa is an exception in this particular and will evidently remain so for some time at least, although numerous Ohio farmers are occasionally growing seed for their own use. The advantage of producing a crop from acclimated seed is well illustrated in the corn work of the Experiment Station. It is equally reasonable to expect that an improved strain of alfalfa will in time be produced from home grown seed which will be better suited to the particular soil requirements of Ohio than that now used.

Variety tests on the Station farm. Special tests conducted upon the Experiment Station farm at Wooster, by the Agronomy Department have shown that the source of seed is a factor. When seeds from different sources are sown side by side in cultivated rows, some strains withstand the winter much better than others, this being particularly noticable in seedings of several years' standing. Variations of growth are also noticable; certain strains having their own peculiarities, such as a larger number of stalks from the same root, low bunchy growth, tall and slender plants, heavy foliage, coarse woody stems, etc.

Cooperative variety tests. A number of tests have also been conducted by the Experiment Station in cooperation with farmers in various parts of the State, in which varieties of alfalfa seed, which were supplied by the Bureau of Plant Industry, U. S. Department of Agriculture; were compared in the hope of finding sources of seed from which might be secured something of special value for Ohio growers. So far, the work has shown little if any evidence of marked difference of value. The same point has been studied during the past summer's investigation in the field with no tangible proof upon which conclusions can be based. One serious obstacle in this investigation is a lack of knowledge among seed dealers as well as growers relative to the source of seed purchased. Should a farmer secure a seeding of especially valuable quality in few cases could he have any assurance of securing more seed from the same source.

SEEDING PROBLEMS

Unnecessary trouble in preparation for seeding. In a few localities of the State, to which alfalfa is particularly adapted, unnecessary time and expense have been expended in securing a stand where less expensive methods would have succeeded equally well. Failures in growing alfalfa under soil conditions which are particularly unfavorable have caused many to conclude that alfalfa is a comparatively difficult crop to seed, which is no more true than to say that potatoes are a difficult crop to grow in Ohio because there are some sections of the state in which potatoes are largely bought for home consumption owing to the difficulty of growing them.

The numerous methods of seeding have no doubt often been a stumbling block to the prospective grower, while a classified association of methods with environments would in most cases reduce the reasonable methods of procedure for any one field to a small number.

Reseeding old alfalfa fields. Alfalfa has been seeded after almost all of the other farm crops with no particular failure that can be traced to the effects of the preceding crop. Following alfalfa with the same crop after a seeding of long standing is probably not a wise

plan, as illustrated by the results of two growers who succeeded in growing profitable crops from the first seeding for ten years, when it was decided to break the ground and immediately reseed. In both fields the second seeding failed with no apparent reason. Both farms are especially well adapted to alfalfa, as would be indicated by the first seeding remaining profitable for so long a time. One of the fields mentioned is owned by an orchardist who feeds the alfalfa to sheep in order to provide manure for enriching the orchard. When it is remembered that alfalfa is especially rich in the soil elements of plant food and that three crops were removed each season for nine years at least, with nothing returned to the field, it is not remarkable that a shortage of plant food existed for the young alfalfa plants starting upon the same soil. An exception to this failure was observed in Coshocton county, in the case of an overflow field which was successfully reseeded after standing for the same time as the previously mentioned fields. Aside from the question of plant food, however, most farmers consider the other principles of crop rotation of sufficient value to induce them to follow some kind of rotation.



Fig. 13. July seeding of alfalfa and red clover side by side, on the Tuscarawas river in Tuscarawas county. Photographed in October of the same season showing a larger growth of alfalfa on the right than of red clover on the left.

Previous crop. An increasing number of farmers are growing an early maturing crop, such as peas, potatoes, sweet corn, etc., which can be removed in time to successfully seed to alfalfa the same season. The cultivation of such crops prepares an ideal seed bed in most cases, which is comparatively free from weeds. The one common objection raised against this practice is the possible lack of moisture due to the demand of the previous crop. In cases where

this is considered a menace to the stand of alfalfa it is a frequent practice to give the same cultivation with the early crop omitted. This method has the advantage of killing the weeds and retaining the maximum amount of moisture.

Hardiness of alfalfa. The ease of seeding alfalfa is well illustrated in a number of comparisons with red clover, in some of which alfalfa grew and the red clover failed. Where conditions were favorable it was observed in Preble, Butler and Tuscarawas counties that alfalfa is as readily seeded as red clover. It is further shown that, under favorable alfalfa conditions alfalfa makes a larger growth during the first season than does red clover (see Fig. 13).

The seed of alfalfa is considerably larger than that of red clover and for that reason should start a more hardy plant than red clover. The experience of growers would indicate that the more exacting soil requirement of alfalfa is the only cause of difficulty in seeding it. For a number of years growers have been advising beginners to mix a small amount of alfalfa seed with red clover seedings. This has resulted in alfalfa being scattered through many fields of red clover where it seems able to compete with the clover.

The natural hardiness of any grass cannot be more accurately determined than by placing that particular grass in actual field competition with other grasses for a number of years. Such an experiment was arranged on the Morgan county fair grounds twenty years ago, in which twenty-four grasses and legumes were seeded in small plots. The field has remained in grass ever since, thus giving each plot an equal chance. The alfalfa, unlike several of the others, has not extended its area in the least from the original seeding; but the greater number of the others have been eliminated within the 20 years by the "survival of the fittest", blue grass having largely taken their places as would be expected. The alfalfa, however, continues to grow, although a well established blue grass sod has occupied the same plot for years. It is certainly safe to conclude that any plant that can compete with blue grass under field pasture conditions for twenty years and not be eliminated has some claim for hardiness under Ohio conditions.

Seeding alfalfa in growing corn. Repeated trials have proven that it is possible in a number of sections to seed alfalfa in the corn field after the last cultivation of the corn.* Under slightly less favorable conditions a Logan county farmer has succeeded in the same way with the exception that only one stalk of corn was grown in each hill. This had the advantage of the same cultivation with less

*Circular 107, Ohio Experiment Station.

drain upon the moisture of the soil than if a full crop of corn had been grown. Also the less amount of shade made by the single stalk of corn in each hill improved the conditions for the young alfalfa. The yield of corn from one stalk in each hill would make this method of seeding alfalfa much less expensive than where the use of the ground is lost for an entire season, as is so often considered advisable. The repeated experience of growers who have found alfalfa more hardy than red clover under the same conditions would suggest possible value in the experience of an Athens county farmer who has found that red clover is much more certainly secured upon his farm when seeded upon fairly compact soil than upon freshly plowed soil. He is of the opinion that the same is true in seeding alfalfa. Judging from the success of various farmers who have alfalfa mixed with red clover, there is a possibility of our really having made alfalfa seeding harder than necessary under certain conditions. As in seeding red clover, an important factor in seeding alfalfa is evidently the supply of proper moisture for the delicate young plants before the roots have penetrated deep into the soil.



Fig. 14. Early and late seeding on Tuscarawas county infirmiry farm in cooperation with the Experiment Station, showing late seeding (on the left) to be more free from weeds than the early seeding.*

Time of seeding. Behind all of the perplexing methods that have been practiced in seeding alfalfa, is seemingly the fundamental advantage of seeding as early as possible in the spring in order to secure a large root system to better withstand the winter and, prob-

*In the experiments of the Agronomy Department of the Ohio Experiment Station, which have been carried over several seasons and which have included various nurse crops and preparatory crops, the only satisfactory stands have come from mid-summer seeding on spring fallowed land with no nurse or preparatory crop. These experiments have been conducted under soil conditions belonging to the third class of those mentioned on page 23.—C. E. THORNE.

ably even more, the extremes of weather during early spring following. Just to what extent this is practical would depend upon a particular knowledge of how late it will be necessary to delay seeding in order to safely eliminate the injury from spring weeds.

Combination seeding. Not many farmers have seeded alfalfa with timothy as is so much practiced with red clover. A few such seedings have been located throughout the State which have proven very satisfactory. In such a combination either the timothy is cut quite immature, when the first crop of alfalfa should regularly be cut, or no harvesting is done until the timothy is in the usual condition for hay. In the latter case the following crops that season will be mostly pure alfalfa, while in the former case there will be some timothy in both the first and second crops. One grower in Washington county has been following this method successfully for eight years. In a field seeded four years ago, which had been allowed to stand unharvested until the timothy was ready to harvest, the alfalfa was well filled with seed. The alfalfa was not a uniform stand in all parts of this field and in places where it was thickest the timothy had made so much larger growth that it had lodged. A number of similar examples were located, both in and out of the limestone areas of the State, where alfalfa has in the same manner improved the grass with which it was growing. From investigations recently reported by the Cornell Station it would be safe to infer that the quality of the non-leguminous grass would also be improved.*

Blue-grass. In a number of fields the alfalfa plants are surrounded with a blue-grass sod extending over the whole area. Under such conditions the blue-grass has invariably been of a more luxuriant growth than when the legume was not present. The value of this method of securing a stand of blue-grass is not generally appreciated. However, a number of farmers recommend it as an ideal way in which to secure a good blue-grass sod or to improve an old one. This feature has formerly been considered only as an impediment to growing alfalfa. Where permanent pasture is desired it may, however, prove to be very valuable.

Implements used in seeding. The mechanical arrangements for seeding alfalfa are various. Probably a large percent of the alfalfa is seeded with one of the many satisfactory hand seeders. On some soils in which the seed will be sufficiently covered no additional covering will be needed, while under different soil conditions it is found best to follow with a weeder, and in yet heavier and more compact soils a harrow is used after seeding. It is a very common practice when seeding with a hand seeder to sow only one-half of

*Bulletin 294 Cornell Experiment Station.

the seed the first time and immediately cross with the remainder at right angles. In this way a more uniform seeding is secured. The weeder-seeder as shown in Figure 15 has proven valuable for a number of years on a light sandy soil in Lake county for seeding both alfalfa and red clover. This implement is apparently worthy of much more general use in soils adapted to the use of the weeder.

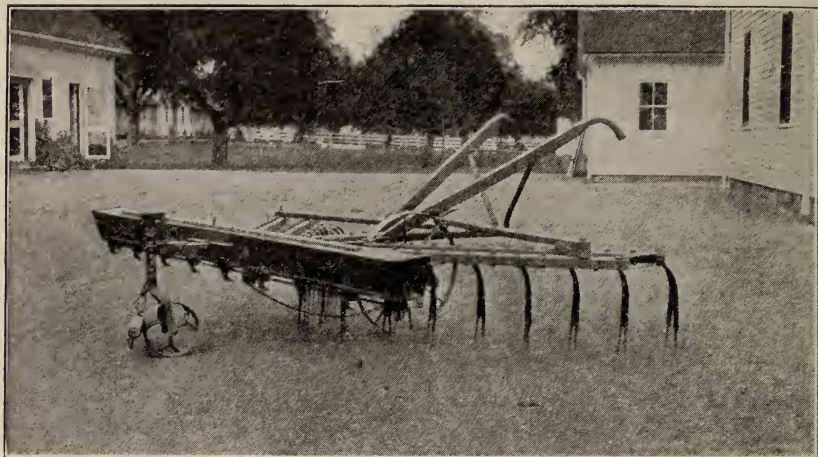


Fig. 15. Weeder-seeder. Combined cultivator and grass-seeder found valuable in seeding both alfalfa and red clover in some of the light soils of northern Ohio.

Many fields of alfalfa seeded to a spring nurse crop are drilled in with a common hoe drill, having a seeding attachment for grass which permits seeding at the same time the nurse crop is drilled. By shifting the dividing board it is possible to drop the alfalfa seed either in front or behind the drill hoes, the decision regarding which will depend upon soil conditions to be determined by trial. The disc drill can be used in the same way but it has not proven as satisfactory on some soils as the hoe drill. The ridge between the drill rows is a valuable protection in case of dry weather soon after seeding. It is also true, however, that a dashing rain may remove more of the seed with the ridge, than without it.

• **Amount of seed per acre.** Although the amount of seed sown per acre varies to extremes over the State, there appears to be no convincing evidence that any section should vary in this particular from the amount proven best on the Station farm at Wooster, which is about 15 pounds per acre.* It is not uncommon for a poorly prepared field to show poor germination that may be attributed to a light seeding, when in fact a lack of moisture is really the cause. On certain soils that drain slowly and are subject to injury from alternate freezing and thawing, some growers seed more heavily for a protection against such injury.

*Circular 91, Ohio Experiment Station.

In general, then, 15 lbs. per acre is an abundance of seed unless the conditions are unfavorable. The price at which alfalfa seed sells would indicate the wisdom of avoiding these unfavorable conditions.

Reseeding. Where partial stands of alfalfa that appear too valuable to destroy have been secured, various methods of reinforcing the stand have been tried. Only one success has been reported within this investigation, and even in this instance while the stand secured was good in some places, in other places it was almost a failure. When seed is sown among old plants the trouble is that ordinarily the old plants both, by their shade and root systems, so weaken the young plants near them that they fail to grow. All the attempts at thickening up the stand which were observed have been in soils that were not the most favorable for alfalfa. From this it would not be safe to conclude that alfalfa cannot be thickened under more favorable conditions. However, this is seldom required upon ideal alfalfa soil.

Inoculation. Alfalfa is now grown so generally and has been so for so many years that inoculation is present to such an extent that its effect can only be studied in the newer sections where it has not been grown before, and very probably in many such places sweet clover, which has been proven to give the same inoculation as alfalfa, may be found growing. It is probably due to such conditions that in so many cases results have been contradictory in this respect. A few instances are at hand, however, showing that under certain conditions artificial inoculation has brought about a distinct improvement in the crop produced, whereas in most fields no attention has been or need be paid to it.

The effect of inoculation was apparent within three weeks upon a new seeding of alfalfa in Logan county. This was easily detected by the darker green color of the field treated with soil from an old alfalfa field. Many farmers who had trouble in securing a stand in former years are at present succeeding with the same methods. They attribute their success to the presence of inoculation which was formerly lacking.

Nodules. So far as examinations were made the alfalfa which continued to grow well showed inoculation as indicated by the nodules on the roots of the plants, while in a number of unsuccessful fields no nodules were found (see Fig. 16). An interesting example was located in Licking county where individual plants in the same field were of two distinct colors. The dark green plants were found to have nodules on the roots while the yellow and less thrifty plants were not so supplied. Another instance, in soil lacking in lime, was

observed in Washington county, where nodules of exceptional size were found in a portion of the field where a brush pile had been burned. The fibrous roots to which the nodules were attached had entwined the particles of charcoal, forming clusters of nodules.



Fig. 16. Nodules on the fibrous roots of alfalfa which are necessary for a profitable crop to continue. Photo supplied by Dept. of Agronomy.

In Shelby county nodules were located upon the tap root of a plant that was removed from the soil (see Fig. 17). This was not observed elsewhere in the fields examined.

THE USE OF MANURE AND FERTILIZERS

Top-dressing. The application of manure previous to seeding is a common practice and may cause alfalfa without inoculation to grow fairly well for a short period, but the effect is not permanent. The benefits of manure as a top-dressing are commonly apparent. Another common practice is to apply the manure lightly during the winter in order to have it well settled before the first crop is harvested the following spring. In one instance in Logan county, where the manure was applied by hand at the rate of twenty-five loads per acre, the results were injurious. This was repeated for

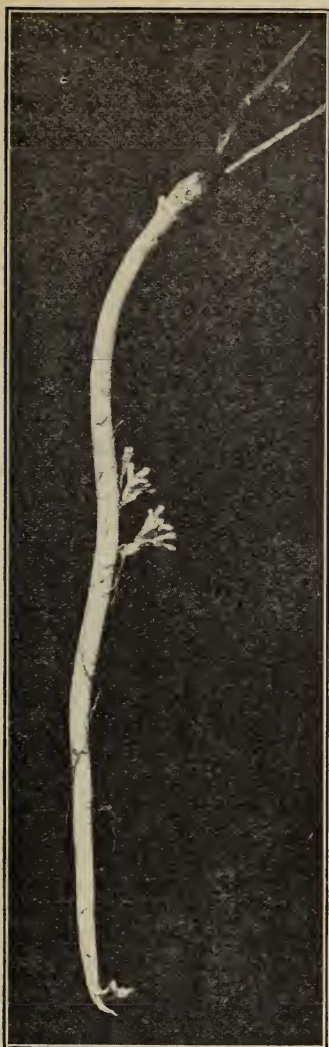


Fig. 17. Nodules on a tap root of alfalfa plant. They are commonly found upon the fibrous roots. Their presence is considered a safe guide to soil inoculation.

three years with the same results. The reason given by this farmer was that alfalfa is naturally a dry climate plant receiving its moisture from deep in the soil, while by the application of a heavy covering of manure additional moisture is retained near the surface during the spring when the soil contains the greatest amount of moisture. In the same county is another instance of injury due to nearly the same cause. In this case manure was hauled from the chicken house during the early spring and scattered over the alfalfa by hand. The alfalfa was so much injured that the growth ceased and the plants turned yellow as far as the application extended. The effect of feeding hogs is very marked upon a portion of a limestone hillside in Preble county. The hogs were fed during the early fall of 1909 and the following spring the field was plowed and seeded to alfalfa in June. A perfect stand of alfalfa now grows upon all of the field excepting the spot where the hogs were fed new corn and there it is a complete failure. In contradiction to this observation is another field in Montgomery county upon which hogs were also fed previous to seeding alfalfa upon a clay hill and upon which the best alfalfa is now growing upon the spot thus manured. Much further evidence will be necessary to justify final conclusions regarding the effect of heavy applications of manure upon alfalfa under the various conditions that are to be found over the State.

Commercial fertilizer. Very little commercial fertilizer has been used throughout the State in starting alfalfa and the experience of those who have used it would indicate that where other conditions are correct it is seldom needed. The effect of a brush pile having been burned upon soil afterward seeded to alfalfa has proven a

marked benefit in a number of instances. A conspicuous improvement in alfalfa growth has been observed in Union county where brick were formerly burned. Judging from this last fact the inference may be drawn that the benefit of burning the brush may have been from the effects of the burning as well as from the effects of the ash. This is further confirmed by the test of one grower who applied wood ashes without results.

CULTIVATING ALFALFA

Various harrows used. The practice of cultivating alfalfa to eradicate grass and weeds is rapidly increasing in favor with farmers in general, although trials have proven it to be impractical to cultivate it during the first season. Numerous styles of harrows have been used in experiments made in this connection. The work along this line year after year with various implements at the Experiment Station has called attention to the possibilities of such a practice. Manufacturers of harrows are now awake to the coming demand for a style of harrow better adapted to the work than anything yet manufactured. It is an opinion among at least quite a number of growers who have attempted to cultivate alfalfa that the coming harrow must be some style of spring or spike-tooth. Injurious results from using the various forms of disc harrows are experienced in cases where cultivation is delayed for a few days after cutting the crop of hay. This seems to be due to the discs injuring the young, tender shoots after they have attained some size. However, a grower in Fulton county, having a quick-draining soil, finds it practical to disk in the early spring before the alfalfa has commenced to grow. One grower reports an increased crop where he disked after harvest on Saturday, while an adjoining strip given the same treatment the following Monday was injured. The same objection is not raised against the spring-tooth harrow, which does not injure the young sprouts above the surface of the soil like a cutting disc. In one field visited in Ross county the spring-tooth was used without injury eleven days after harvest and when a new growth was six inches high. The vibration of the spring teeth is also considered an advantage over the disc or spike-tooth, in that it more completely removes the dirt and weeds from the grass roots, while if rain follows soon after, the disc often merely resets the weeds instead of removing them. Another grower reports following the deep cultivation with either a light, spike-tooth harrow or a weeder, and sometimes both, to shake the dirt more completely from the weeds and grass roots. The latter treatment is more effective if delayed until the loose dirt has become as dry as possible, when it is more completely removed from the roots of the plants.

Time to cultivate. When cultivation is primarily to kill weeds probably the most satisfactory time has proven to be after the second crop has been removed. This is due to the fact that the days are longer and warmer with the maximum amount of sunshine, all of which are helpful in eradicating grass and weeds. There is commonly less moisture in the soil at this time than when the first crop is harvested, which is also helpful in the same way. The weeds and grass have made most of their growth before the third crop is harvested and for that reason little benefit would result to that season's crop of hay if cultivation was delayed until after this time.



Fig. 18. Springtooth harrow with specially constructed points, more narrow than will be found upon the market. This harrow successfully eradicated blue-grass sod and plantain from an old alfalfa field in Ross county. Eleven cultivations were given to part of the field during one season, without injury to the alfalfa.

Special harrow. One grower made a special harrow for alfalfa cultivation by having a blacksmith repoint the teeth of an old springtooth harrow as per Fig. 18. This harrow was repeatedly run over the alfalfa in different directions until little but the alfalfa remained. Occasional spots received as many as eleven cultivations within the season. Shortly before the fourth crop was ready to harvest a second visit was made to the same field. Bunches of dead grass and plantain leaves were scattered over the field, and practically all the plants other than alfalfa were destroyed. The increased yield of hay has been such that the owner plans to continue the cultivation another year in order to conserve the moisture, although it will not be necessary for the same purpose for which it was begun last year.

While the purpose of the cultivation last year was to eradicate the grass and weeds, the effect from the conservation of moisture by the continuous cultivation was doubtless of much value.

Blue-grass sod broken and seeded to alfalfa. The field shown in Figure 19 is in a good blue-grass section of Ross county and has been in alfalfa a number of years with the grass and weeds well established.



Fig. 19. Alfalfa field in Ross county, which was cultivated 9 times during one season, as it appeared shortly before harvesting a bounteous fourth crop.

This field was cleared of all grass with one season's cultivation to the entire satisfaction of the owner. On the other hand, the idea of some growers is that it will be much more practical and easy to commence cultivation before the grass and weeds have become permanently rooted than to remove them after they are once well set in the alfalfa. One experienced grower in Hamilton county who cultivates alfalfa prefers a blue-grass sod, broken up and seeded to alfalfa, to any other crop. There are few weeds to bother and when the blue-grass returns the second year the cultivation easily removes it before it is well rooted. The alfalfa makes a more satisfactory growth upon such sod than elsewhere upon this farm.

Injury to roots from cultivation. A few diseased roots may be destroyed by cultivation, but it is difficult to find a single healthy root that has been so injured. The hardiness of alfalfa roots is shown by the frequency with which they are found in fields planted to corn after an alfalfa sod. The illustration in Figure 20 is of such an alfalfa root, taken from between the rows of corn after cultivation in the heavy clay soil of southern Ashtabula county, where the prevailing opinion is that alfalfa cannot be made to grow. Repeated



Fig. 20. Alfalfa root taken from between two corn rows in an alfalfa sod field in Ashtabula county. Repeated cultivation of the corn has injured the plant causing it to start a new shoot below the crown.

cultivation had injured the plant growth to such an extent that a new growth was started considerably below the crown of the plant, as may be noticed in the photograph.

INJURY DUE TO VARIOUS CAUSES

Yellow condition a result. Besides the injurious effects of heavy mulching, already mentioned, which may have been due to moisture conditions, the yellow condition of the alfalfa was directly traced in one instance to the effect of manure. This was on a Logan county farm where, previous to seeding alfalfa, strips of both silage manure from the cow stable and ordinary horse stable manure were applied. The alfalfa quickly turned yellow where the manure from the silage-fed cows was used and shortly afterward the same was true of the horse manure strip. Adjoining strips with no manure did not show the yellow condition until shortly before winter, while still another strip on which lime was applied failed at any time to show any signs of turning yellow. Quite frequently such trouble is experienced the first year, when the plant is feeding near the surface, but is overcome later on when the roots reach a greater depth.

Wise to clip whenever growth is stunted. When alfalfa has been checked by drouth, or any other cause, so that growth has ceased, it does not appear possible to renew the growth by creating favorable conditions at a later period. The new shoots will utilize the renewed energy instead of its returning to the old plant growth. An instance of this was observed in Lake county, where the extreme dry weather had completely checked the growth of the second crop when about one foot high. Some time afterward rain came and moistened the soil, causing the new shoots to grow among the former growth. At the time of the visit to the field the new shoots were as high as the old plants and of a dark, thrifty appearance, while the plants of the former growth were of a dull, unthrifty color and no larger than during the dry weather. This being true it would appear to be wise to clip alfalfa in case growth has discontinued for any reason, as it will not increase in value and is possibly an injury to the following crop growing amongst it.

Premature cutting injurious. This fact is in no way contradictory to the experience of numerous growers over the State who find that the premature harvesting of normal crops of alfalfa, if carried to the extreme, will result in a yellow condition of the following crop. The observation of a few growers is that harvesting before the new shoots for the following crop are sufficiently strong to withstand the sunshine, which is suddenly allowed to come upon them when the former crop is removed, will result in the following crop turning yellow. A grower of 18 years' experience with alfalfa in Lake county reports loss in 12 different years by the crop turning yellow and that by accident he found that the trouble could be avoided by more mature harvesting. For this reason he now harvests but two crops each season. He values the two crops having a vigorous growth more highly than the three formerly harvested, when some of them were more or less yellow. Fields are frequently found in which a part of the field, harvested possibly a few days earlier than the remainder, shows the next crop of a yellow unthrifty appearance, while the later cutting is followed by a fine healthy growth.

Injury from long stems remaining uncut. Another condition that has been reported frequently as injurious to the following crop is when under exceptionally favorable conditions in parts of the field the alfalfa has been heavy enough to lodge, so that in harvesting, the long stems remain uncut by the mower, thus leaving a long stubble upon the field. In such cases the following crop does not grow as well as under normal conditions.

Injury from not harvesting late crop of hay. The same idea is further illustrated in the experience of an extensive grower in Montgomery county, who after harvesting the fourth crop from a part of one field allowed it to remain uncut upon the remainder of the field during the winter. The part from which the hay was harvested was not injured by the winter or spring, while the part unharvested was seriously damaged. His observation led him to believe that the roots with no tops were practically dormant during the winter and spring while plants in the same field with large green tops on them remaining alive for a considerable time were more affected by changes of weather, the living tops acting as a conductor of changes in temperature to the root system. In fields where drainage is not perfect this injury may be more than overcome by the value of the tops as a protection from freezing and thawing. Many farmers are harvesting the fourth crop and if it is found necessary a much cheaper protection can be had in the form of a light application of straw or other mulch.

Advantage of short stubble. In this connection a few farmers have concluded that it is best for the succeeding crop to cut the stubble as short as possible and yet not clip the new shoots that may have already started. When it is borne in mind that an old stubble must die back to the crown of the root after each crop is cut and the sap be suddenly transferred to the new shoot, this idea is as reasonable as when applied to the same principle in forestry and horticulture.

Methods of pasturing. Notwithstanding the fact that in the opinion of most growers, it is not practical to pasture alfalfa it is not uncommon to find fields that have been successfully pastured with the various farm animals. In most instances the regular clippings are made, although the hay may be left upon the ground. The injury to the roots from trampling is evidently less from pasturing in fields seeded in combination with other grass, thus forming a sod, which acts as a protection to the alfalfa roots.

Clipping or pasturing while wet. Both pasturing and clipping alfalfa while wet with dew or rain has in a number of cases proved injurious to the following crop, which appeared to lack proper vitality, and finally ceased to grow and took on a yellow color.

Insect enemies. Grasshoppers have in a number of instances over the state injured both old and new seedings of alfalfa, although in this respect there appears no reason for more trouble than with red clover. In Montgomery county one alfalfa field was ruined by small green bugs which the owner reported as first appearing a few years ago and continuing each spring until about the time of

harvesting the second crop. During the past season it was difficult for the driver to see while mowing the second crop owing to the cloud of these small insects which were disturbed by the team and mower. Later in the season when the field was visited it was not possible to find a specimen of the damaging insect.

THE VALUE OF ALFALFA AS A WEED EXTERMINATOR

Wild morning glories killed. The value of alfalfa as a weed exterminator has been accidentally discovered in a number of instances. It has been found to be the means of eradicating a number of our worst weeds in several localities over the state. We have the statements of growers in four different counties who have eliminated wild morning glories from their fields by two or three years' harvesting alfalfa. This weed is one of the most persistent and frequently renders rich valley soil almost worthless for many of the farm crops. On some of the fields reported this pest has been so bad that all other means of exterminating it have failed and very little could be produced upon the ground. The frequent clippings received while in alfalfa, and the quick shade which followed each cutting of hay, have killed out the weeds. One grower stated: "Freeing this rich valley soil from the wild morning glories, which for years we have been unable to control, is worth all the trouble and expense of growing the alfalfa, even had it been of no value other than to free the field from the weed pest".

Other weeds. Another persistent weed—Canada thistle—is also reported, by one grower in Lake county, to have been destroyed in an alfalfa field after a few years' harvesting. This, however, is the report of but one experience. The value of alfalfa as a destroyer of a certain class of weeds is no doubt exceeded by no other farm crop, yet this important factor in favor of it has had but little attention on the part of farmers, and is probably not fully appreciated by those who could often use the crop to good advantage with this in mind. While weeds of a certain kind, such as plantain, are but little injured by alfalfa, it is quite evident that a number of our worst weeds will readily give place to alfalfa within a few years. It is also quite possible that with a number of weeds the regular clipping for the same period of time would have the same result, even though the alfalfa were not present.

NUMBER OF CROPS HARVESTED

Length of season varies. The number of crops of alfalfa harvested annually varies with the season as well as the location. During occasional seasons in southern Ohio, where the soil is exceptionally favorable, five crops are harvested when in the

blossoming stage. An extensive grower on the Little Miami River, who has kept an account of hay harvested for the past ten years, shows an average of five tons per acre per year for the entire period. Five crops are frequently harvested on this farm during a single season, and even in northern Ohio four crops are not at all exceptional throughout a few favorable sections (see Fig. 21). Three crops of hay are commonly harvested each season under the more unfavorable surroundings in the state where alfalfa growing is found practical. As already mentioned, a few growers who have alfalfa in combination with other grasses, or to avoid the following crop turning yellow, have found it wise to cut less often.



Fig. 21. Fourth crop of alfalfa hay harvested on upland in northern Van Wert county, estimated at one ton per acre. This field is near the southern border of the old lake bed area shown in Fig. 4.

THE PRODUCTION OF ALFALFA SEED IN OHIO

Seed production is at the expense of two hay crops. Where attempts have been made to grow a seed crop it is commonly at the expense of two hay crops, unless the season is long enough to mature the last crop for seed. Of course in either case considerable feeding value is contained in the haulm after seed has been hulled. However, the experience of those who have attempted to grow the seed in this state is that it has seldom been profitable, although comparatively few growers have given the matter any attention. Work of the Agronomy department at the Experiment Station has shown that alfalfa will seed much more readily when mixed with some other grass, as timothy or blue-grass, than when growing alone. Investigations over the state verify this fact in a number of instances. In

Ottawa county an extensive grower left the later crops on two fields for seed, one of which was seeded alone and the other with timothy. A field of two and one-fourth acres seeded alone was allowed to mature seed after the second hay crop of the season had been removed. There were two wagon loads of this seed crop which made but one and one-half bushel of seed. The other field of six acres, which was seeded with timothy, was allowed to mature seed after the first crop of mixed hay was removed. The second crop in this case was pure alfalfa, making only one load for the huller from the field, which yielded six bushels of seed. A few exceptions have been noted in which fair seed crops have been produced from alfalfa seeded alone (see Fig. 22).



Fig. 22. Alfalfa field in Van Wert county heavily filled with seed during wet weather, harvested the middle of October.

Various crops saved for seed. It does not appear that any particular crop is always best to save for seed but rather, as in the growing of red clover seed, that the weather is an important factor. In a Hamilton county field the fourth crop was allowed to mature seed. This crop was tramped with horses which removed the seed from the stems but not from the hulls. Two flour barrels were filled with seed in this shape from $2\frac{1}{2}$ acres. This seed was mixed with oats the following spring and successfully seeded by a single drilling and a satisfactory stand secured.

METHODS OF HANDLING ALFALFA HAY

Canvas covers. Harvesting methods have not been found to vary in general from those found best in growing red clover for hay. The first crop, coming earlier than red clover, has less favorable

weather, and on this account a number of growers have canvas covers with which to protect the cocks of hay from rain while curing in the field (see Fig. 23). Most farmers look upon bunching the alfalfa in the field for partial curing as requiring extra labor, besides adding to the risk from weather.



Fig. 23. Alfalfa hay in Ross county curing under cloth covers which are five years old, costing 12 cts. each for 40-inch square covers.

Alfalfa hay thin on the ground. There is one advantage in harvesting alfalfa often that may in part offset the less favorable weather conditions and that is, owing to its being thin upon the ground, it dries more quickly. The shorter period of growth produces stems that are smaller than those of red clover, which is also an advantage in curing.

Alfalfa stands more rain than red clover. The experience of growers is that alfalfa hay will stand more rain than red clover without injury. Hay that has remained on the field during rainy weather and is later removed solely to prevent injury to the following crop has been greedily eaten in so many instances by stock grazing upon good pasture, that those who have had such an experience no longer throw away weathered alfalfa hay.

The advantage of mowing in the afternoon. One Champaign county grower has concluded that the loss of moisture that takes place in the heavy alfalfa in the forenoon is more rapid in uncut hay than in that cut in the early morning while it is full of the moisture accumulated during the night. For this reason he does not start the mower until about noon. When this plan is followed the rake is often started to advantage the following morning, as soon as the dew is off. Especially is this true in the case of crops harvested late in the season when the conditions are more favorable for curing.

Tools used in making alfalfa hay. Good hay is being made both with and without the use of the hay tedder. However, its use does not appear to be as essential with a light hay crop, harvested three or more times a year, as with red clover making a much heavier crop at one cutting. A side-delivery clover seed buncher has been successfully used in harvesting alfalfa hay later than the first crop, when the curing process is more rapid. This method places each mower swath in a windrow which can be moved either with a rake or tedder as desired.

Curing hay. If the crop is thin on the ground during hot sunshine it is possible for the leaves to become crisp and even drop off before the curing is completed sufficiently for storing in the barn. It is commonly considered that the curing process is more rapid while the leaves remain green and can help conduct the moisture from the stems. There is little danger of the leaves becoming lost at the time of harvesting the first crop with the shorter periods of sunshine at this season. It seems wise to get the later crops in the cock to cure before the leaves are lost. The superior keeping quality of alfalfa hay as compared with red clover is further shown by the ease with which it is kept in stacks, although the economy of stacking such a valuable product is to be questioned.

Methods of storing hay. An intensive dairyman in Ross county has successfully run alfalfa through a cutting box as it came from the field, and with a blower attached to the cutter the labor was little more than in the regular way of storing hay. In this particular case power was readily available at any time with small cost connected with the dairy. The hay kept perfectly in this way but the plan was discontinued owing to the greater amount of heat generated in the curing, which it was feared might result in more danger of burning the buildings.

FEEDING ALFALFA

Soiling. Numerous town lots in various parts of the state have been seeded to alfalfa and are being soiled to supply a horse or cow during the growing season (see Fig. 24); chickens are also profitably fed in the same way.

Pasturing with poultry. Town lots are commonly very rich, naturally well drained, and will usually withstand worse treatment than the average field. One poultry grower has divided his poultry yard into two parts and successfully pastures alfalfa by alternating chickens between the two. Another covers his alfalfa seeding with wire netting suspended at such a height that the poultry standing on top and picking down through it can not reach the young shoots

until they are well started. Fowls are quickly attracted to an alfalfa seeding near farm buildings and prefer it largely to other grasses. The constant nipping of the points by fowls is frequently reported to be injurious to alfalfa. However, in one farm experience the part of the field over which chickens scratched most produced a crop of darker green color, which was attributed to the cultivation caused by the scratching of the soil.

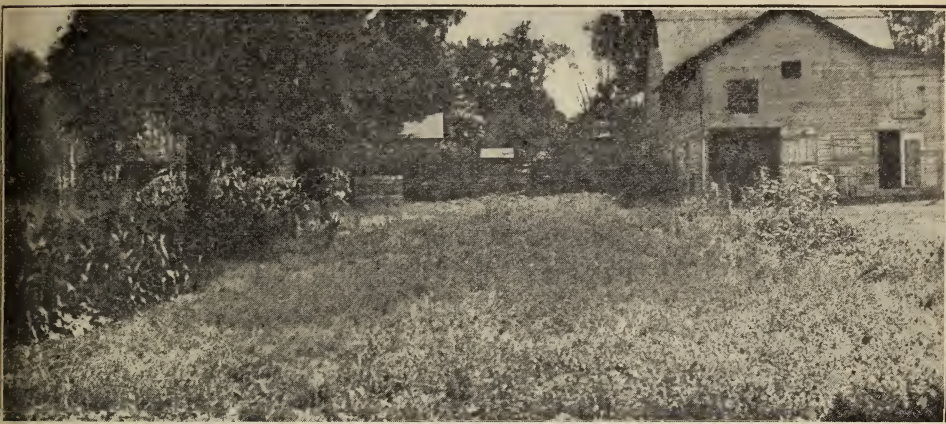


Fig. 24. Townlot in Fulton County seeded to alfalfa for several years which is successfully soiled during the entire growing season.

Silage. Alfalfa has been found well adapted for the silo in connection with corn. It frequently occurs that the third crop of alfalfa is ready for harvest at the time that corn is ready for the silo. A dairyman in Champaign county reports that his best feed is silage composed of one-third alfalfa and two-thirds corn. The advantage over red clover for silage is its more solid stems in place of the larger and more hollow stems of red clover. The larger amount of air contained in red clover silage due to this difference is thought to be the cause of its occasionally keeping poorly in the silo. It is seldom necessary, however, to make silage of alfalfa, as the hay is palatable and when properly cured and fed in moderation all of it is eaten by farm animals.

Poultry and hog feed. The hay is frequently cut in small lengths and fed to both hogs and poultry. It may be fed either dry or scalded and mixed with a concentrate. Several hog raisers have eliminated all feed but corn for brood sows during the winter excepting a small amount of alfalfa fed in this form. On a general stock farm another method found to be practical is for the hay to be thoroughly tossed about as it is thrown from the mow in order to remove as many of the leaves as possible before

it is fed to the horses or cattle. This provides a large amount of leaves that make ideal feed for the hogs and poultry during the winter.

Alfalfa meal. The small amount of waste in feeding alfalfa hay would not indicate a great advantage from alfalfa meal. Only a few mills for grinding alfalfa have been located within the State and none are in regular use. Mills are on the market at a reasonable price that will grind grain and that are also guaranteed to grind alfalfa hay into meal providing it is first run through a cutting box. Sufficient observation of this use of such mills has not been made to justify a statement as to what their practical value may prove to be to the growers of Ohio. Alfalfa meal is quite often fed by stockmen who buy the western meal which has been shipped in. No reason is evident for the alfalfa meal producing any larger returns than the same amount of hay. The price of course is considerably higher and its purchase can only be justified in sections where alfalfa cannot be grown, or by those who are moving about with stock, as in the case of showing at fairs, when it is found necessary to have the feed in the most convenient form possible. It remains to be seen to just what extent alfalfa meal will compete with the other protein feeds commonly sold in sacks. Alfalfa meal is now on sale in many stores throughout Ohio and is sold largely to owners of poultry in villages and towns. This feed is palatable and when moistened comes more nearly supplying a summer feed than anything comparing with it in cheapness. One retail dealer in Montgomery county, who was interviewed, has his alfalfa meal shipped direct from the West, where it is ground, and retails it at 2 cents per pound. It is important to purchase meal that has a bright, fresh color and is free from mold, as an inferior grade of hay can be disposed of most easily in the form of meal.

Palatability. Alfalfa possesses a value, aside from the analysis, which is rather indefinitely expressed in the term "palatability".

COMPARATIVE ANALYSIS OF ALFALFA AND SWEET CLOVER

	Protein	Fat	Nitrogen (free extract)	Crude fiber	Ash
*Alfalfa.....	16.48	2.02	42.62	31.38	7.49
†Sweet clover.....	20.93	3.09	42.46	25.21	8.87

*Bailey's Cyclopedia, p. 518.

†Bailey's Cyclopedia, p. 468.

Although sweet clover contains as much plant food as alfalfa, a taste of each will quickly convince anyone that while alfalfa is pleasant to the taste sweet clover is particularly bitter. However, in various sections of the State where alfalfa has not been grown and the less exacting sweet clover grows as a weed, certain farmers have found that by harvesting it while the stem is yet soft and green, stock can after a time be taught to overcome their dislike for it and profitable results be thus obtained.

Bloat. In pasturing alfalfa with classes of livestock subject to bloat, at least the same precaution is necessary as in pasturing red clover. Besides the advantages of blue grass already mentioned, it probably has a distinct value, in combination with alfalfa to be pastured, as a precaution against bloat. Timothy would no doubt have the same value in this particular. Many farmers have lost stock from pasturing alfalfa, when wet with dew or rain, and in some instances death has resulted after it was dried off and while the sun was shining brightly in warm, dry weather. However, no case of injury has been reported from pasturing alfalfa where it was growing with other grasses or where livestock had access to such grasses.

A few farmers have reported injurious results other than bloating from feeding alfalfa hay, but no exact evidence of any particular injury has been received. In most cases it would appear that the trouble has been due to excessive feeding. Few farmers realize that alfalfa is so much stronger than other hay that a much smaller amount is sufficient.

Alfalfa fed to driving horse. A doctor who has an extensive country practice in Hamilton county keeps but one driving horse, which is fed each day but a few ears of corn and a limited amount of alfalfa hay. His experience of years in feeding no hay excepting alfalfa to driving horses has led him to the conclusion that the limited amount of hay fed is the secret of his success. A few liverymen have been interviewed who are feeding alfalfa hay in connection with timothy to good advantage.

Economy of feeding alfalfa on the farm. Excepting in the older sections there is usually little demand for alfalfa hay and it sells extremely cheap as compared with other kinds of hay. In a few sections where it has been grown for a number of years it has a good market. But when the large amount of plant food in the hay is considered it would seem wise to arrange to feed it upon the farm in order to return the manure to the soil. However, the experience of growers who have followed alfalfa with other crops would indicate that the need of this manure on alfalfa ground may not be detected

for a number of years, as might also be true with red clover. This fact may be due to the deep-rooted alfalfa drawing the fertility from a greater depth than other plants and depositing it in the upper root system which on decaying provides considerable plant food readily available for the following crop. A long continuation of this practice evidently would deplete the soil to a greater depth than would otherwise be possible.

PROFIT FROM ALFALFA

Alfalfa compared with corn. Another point to be associated with the amount of plant food removed from the soil is the income from the crop. Few farmers have any accurate records upon which net profits are safely computed. However, comparisons will give a fair basis upon which general conclusions may be based. One grower in Clermont county, upon relatively cheap land, reports the following comparison between the sales of a corn and an alfalfa crop in 1908. The alfalfa in this particular field was 5 years old.

38.33 bu. of corn per acre @70 cts.....	\$26.83
3.55 tons of alfalfa hay per acre @\$12.00.....	42.60
Gross profits in favor of alfalfa on one acre.....	\$15.77

The labor cost for this season was \$1 per acre for the alfalfa field while the cost of the labor for the corn crop was not kept, owing to the more complicated nature of the various operations involved, although it is evident to any experienced farmer that it is several times the cost of the hay crop. The above figures were based upon a 15-acre corn field and 4½-acre field of alfalfa. Figures compiled by Mr. W. L. Elser of this Department show that of 142 fields of corn aggregating 1939.24 acres, grown in various parts of Ohio, the labor cost of growing an average acre was \$10.98. In the same way it was figured the cost of harvesting 31 fields of alfalfa aggregating 140.41 acres was \$3.74 per acre. From a considerably smaller number of fields, regarding which it was possible to secure accurate figures, it was shown that the average cost of seeding an acre of alfalfa was \$5.46.

Rental profits. Another field of 19 acres in Athens county, seeded in 1908 upon overflow land, was rented on the shares and the owner's half in 1909 was sold for \$250 in the field. In 1910 the first three crops were contracted for \$300 as they grew, with the option of the fourth crop upon payment of an additional \$100. The season was so favorable that a fourth crop was harvested, thus producing \$400 for the season, or in other words, a little over \$21 per acre from the 19-acre field for the owner's share (see Fig. 25 and Fig. 26).



Fig. 25. Farm scene in a rich limestone area of Athens county, Ohio, where alfalfa 11 years old is producing 4 crops annually upon hillsides from 300 to 400 feet above the valley. The owner reports reasonable profits upon a \$250 per acre investment from land that is similar to an adjoining farm priced at \$40 per acre.



Fig. 26. Fourth crop of alfalfa on field seeded 11 years ago. Loose layers of limestone are near the surface causing perfect drainage. The preceding photograph was taken from this field.

Profits of feeding alfalfa to cattle. A Montgomery county grower near Dayton reports a yield of 6 tons per acre from a 16-acre field in 1909, for which he was offered \$18 per ton. Instead of selling it he went to Chicago and bought cattle to which it was fed at an additional profit besides returning a large amount of fertility to the soil.

The examples given are probably the extremes, in two of the three cases at least, and cannot be repeated excepting in a few places over the State, although an encouraging standard is raised for those who understand the possibilities and adaptability of their soil.

No farmer will find all the various points gleaned from this investigation of the past summer throughout the State true for his particular case. However, from the experiences of so many alfalfa growers, each reader contemplating alfalfa growing can no doubt profit by some of the mistakes as well as by some of the successes that others have made. The Experiment Station will be glad to be kept in touch with the experience of all growers of this important crop.

SUMMARY

Numerous farmers have been found, in many parts of Ohio, to whom alfalfa is not a new crop.

So far as climatic conditions are concerned, no evidence has been found that northern Ohio is less adapted to alfalfa than the southern part of the State.

An abundant lime supply and thorough drainage are indispensable to the successful culture of alfalfa.

Many successful fields of alfalfa have been found on well-drained bottom lands, such lands usually being comparatively well supplied with lime, but when equal drainage and lime supply have been found remote from the streams, alfalfa is grown successfully.

The ideal drainage conditions for alfalfa appear to be those in which the water level is maintained at a uniform depth throughout the season.

The so-called "nurse crop" is profitably employed with alfalfa only under the most favorable conditions. In less favorable conditions the nurse crop is a protection against weeds that would otherwise be more injurious to the alfalfa than the nurse crop itself, while in the larger part of the State the nurse crop is usually a disadvantage and frequently ruinous to the alfalfa.

Under the most favorable soil conditions alfalfa has been seeded with wheat or oats as successfully as red clover.

Numerous fields of alfalfa have been found which have produced profitable crops for ten years after seeding, but it has not been found practicable to grow alfalfa again upon such fields until after a long period in other crops.

Alfalfa has been found useful in choking out such weeds as wild morning glory.

Alfalfa has in some instances been successfully seeded in combination with other grasses.

Timothy and blue-grass are noticeably improved when growing in combination with alfalfa and when grown in such combinations alfalfa has sometimes been successfully pastured.

Clipping alfalfa when immature or while wet from dew or rain, has frequently resulted in injury to the following crop.

Inoculation has been found advantageous in localities where neither alfalfa nor sweet clover has previously grown, but the necessity for artificial inoculation is becoming less each year, owing to the more general growth of alfalfa over the State.

CONTENTS

	PAGE
Introduction	3
Acreage	4
Alfalfa not a new crop in Ohio.....	5
Peculiar requirements of alfalfa.....	5
Lime, drainage and other factors.....	6
Importance of lime.....	6
Original lime supply.....	6
Coal measure limestone.....	6
Glacial lime supply.....	7
Old lake bed.....	9
Marl.....	9
Underlying limestone frequent in western Ohio.....	9
Glacial limestone supply in freestone areas carried by stream action.	10
Limestone supply in non-glaciated areas carried by stream action...	10
Hydrochloric acid treatment.....	11
Litmus paper test.....	11
Soil auger.....	11
Glacial limestone in freestone areas not moved by stream action.....	11
Old lake bed field growing four crops of alfalfa.....	12
Old lake bed sand growing profitable alfalfa.....	12
Sands vary in lime supply.....	13
Lime supply often more abundant in subsoil.....	13
Application of lime upon field with subsoil rich in limestone.....	14
Sources of lime supply.....	15
Drainage	15
Differences due to lime and drainage.....	16
Surface drainage.....	18
Water table.....	19
An example of a rotation with water three feet below surface.....	19
Natural drainage.....	19
Injury to tile drains.....	19
Effect of streams	20
Southern hills favorable.....	21
Climatic conditions affecting alfalfa.....	21
Latitude.....	21
First hay crop often woody in southern Ohio.....	21
Adaptation of alfalfa to Ohio conditions.....	22
Alfalfa methods locally applied.....	22
Viewpoint.....	22
Nurse crops.....	23
Purpose of nurse crops.....	23
When the nurse crop is profitable.....	23
Oats in Fulton county.....	23
Wheat in Hamilton county.....	24
Hay crop the first year.....	25

Barley as nurse crop.....	23
Pasturing.....	23
Rye.....	25
When the nurse crop is a robber.....	26
Alfalfa vs. red clover.....	26
Varieties of alfalfa.....	26
Acclimated seed.....	26
Variety tests on the Station farm.....	27
Cooperative variety test	27
Seeding problems.....	27
Unnecessary trouble in preparation for seeding.....	27
Reseeding old alfalfa fields.....	27
Previous crop.....	28
Hardiness of alfalfa.....	29
Seeding alfalfa in growing corn.....	29
Time of seeding.....	30
Combination seeding.....	31
Bluegrass	31
Implements used in seeding.....	31
Amount of seed per acre.....	32
Reseeding.....	33
Inoculation.....	33
Nodules.....	33
The use of manure and fertilizers.....	34
Top dressing	34
Commercial fertilizer.....	35
Cultivating alfalfa.....	36
Various harrows used.....	36
Time to cultivate.....	37
Special harrow.....	37
Bluegrass sod broken and seeded to alfalfa	38
Injury to roots from cultivation.....	38
Injury due to various causes.....	39
Yellow condition a result.....	39
Wise to clip whenever growth is stunted.....	40
Premature cutting injurious.....	40
Injury from long stems remaining uncut.....	40
Injury from not harvesting late crop of hay.....	41
Advantage of short stubble.....	41
Methods of pasturing.....	41
Clipping or pasturing while wet.....	41
Insect enemies.....	41
The value of alfalfa as a weed exterminator.....	42
Wild morning glories killed.....	42
Other weeds.....	42
Number of crops harvested.....	42
Length of season varies.....	42
The production of alfalfa seed in Ohio.....	43
Seed production is at the expense of two hay crops.....	43
Various crops saved for seed.....	44

CONTENTS

Methods of handling alfalfa hay.....	44
Canvas covers	44
Alfalfa hay thin on the ground.....	45
Alfalfa stands more rain than red clover.....	45
The advantage of mowing in the afternoon	45
Tools used in making alfalfa hay.....	46
Curing hay.....	46
Methods of storing hay.....	46
Feeding alfalfa.....	46
Soiling.....	46
Pasturing with poultry.....	46
Silage	47
Poultry and hog feed.....	47
Alfalfa meal	48
Palatability	48
Bloat.....	49
Alfalfa fed to driving horse.....	49
Economy of feeding alfalfa on the farm.....	49
Profit from alfalfa.....	50
Alfalfa compared with corn.....	50
Partial profits.....	50
Profits of feeding alfalfa to cattle.....	51
Summary.....	52

Oh 3^c
Safe

Ohio Agricultural Experiment Station

CIRCULAR No. 114

WOOSTER, OHIO, JUNE 23, 1911

PLANS AND SUMMARY TABLES

OF THE EXPERIMENTS AT THE CENTRAL FARM, WOOSTER,

ON THE

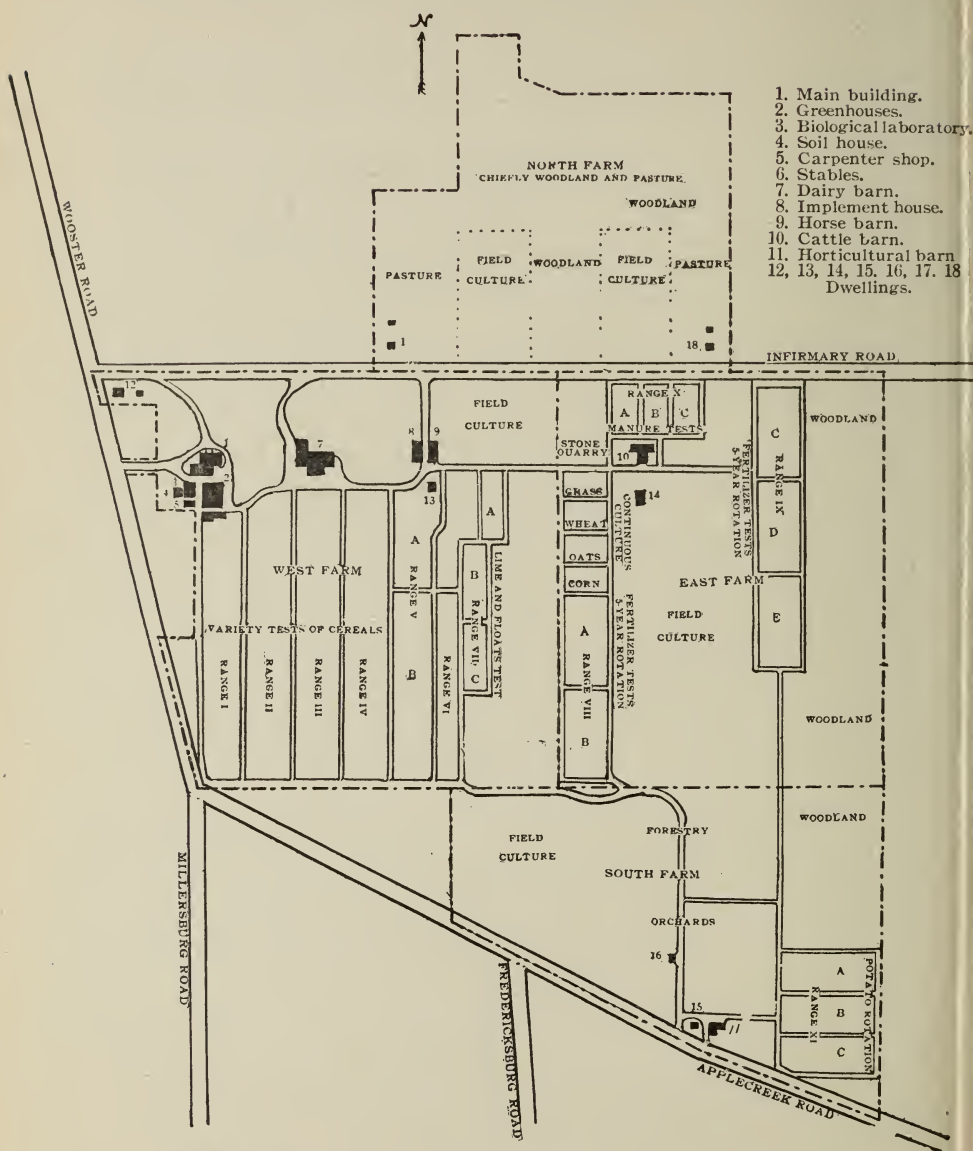
MAINTENANCE OF SOIL FERTILITY

ARRANGED FOR REFERENCE IN THE FIELD.

ANNOUNCEMENT

The experiments reported in the following pages were begun in 1893, immediately after the removal of the Experiment Station to Wayne county. The general plan of this work and the results obtained up to that time are published in Bulletin 110, issued in December, 1899, (now out of print) and again in Bulletins 182, 183, and 184, reporting to the end of 1906. It now seems desirable to follow these general publications with an annual statement, giving as briefly as possible the new data obtained from each successive crop, and referring the reader to Bulletins 182 and 183 for more complete information respecting the nature of the soils under experiment and the general plan of the work.

The results for 1907 are given in Circular No. 83, those for 1908 in Circular No. 92, and those for 1909 in Circular No. 104.



The central farm, near Wooster

FERTILIZERS AND MANURE ON CROPS GROWN CONTINUOUSLY ON THE SAME LAND

Wheat, oats and corn, one acre (10 plots) each, have been grown in this experiment since 1894. The fertilizers are applied to Plots 2 and 8 in arbitrary quantities, while on Plots 3 and 9 the three fertilizing elements, nitrogen, phosphorus and potassium, are given in approximately the same ratio to each other in which they are found in the plant.

The applications to Plots 2 and 8 have in every case produced larger average yields than those to Plots 3 and 9, but this may in part be accounted for by the combined nitrogen which is carried to the soil in rain, thus enabling the crops grown on 2 and 8 to utilize larger quantities of the phosphorus and potassium given in the fertilizer than that required merely to balance the fertilizer nitrogen.

The manure applications on Plots 5 and 6 were intended to carry nitrogen in quantities equivalent to the applications on Plots 2 and 3 on the one hand and 8 and 9 on the other, estimating the manure to carry 10 pounds of nitrogen per ton, but actual analyses of manure made during recent years indicate that this estimate was too high for open yard manure, such as is used in these tests. The average application of phosphorus and potassium in the manure closely approximates the average given to the four fertilized plots.

In this test the corn and wheat show a rapid falling off in yield on the unfertilized land during recent years. The oats also show a reduction in yield, but not so great as that of the other crops.

It is much more difficult to control the weed growth in the wheat and oats grown continuously than where the same crops are grown in rotation, and it was necessary a few years ago to divide these tracts and fallow the two ends in alternate seasons in order to destroy the weeds. Latterly the entire plots have been cropped again.

Diagram I shows the arrangement of plots and plan of fertilizing in this experiment, and the general outcome is shown in Tables I and II, which give the yields by periods.

DIAGRAM 1: PLAN OF FERTILIZING IN CONTINUOUS CULTURE

PLOTS ONE-TENTH ACRE

Fertilizing materials in pounds per acre

Wheat

- | | |
|----|---|
| 1 | None |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 120; dried blood, 50* |
| 3 | Acid phos., 60; muriate potash, 30; nitrate soda, 120; dried blood, 50* |
| 4 | None |
| 5 | Yard manure, 2½ tons |
| 6 | Yard manure, 5 tons |
| 7 | None |
| 8 | Acid phos., 160; muriate potash, 100; nitrate of soda, 280; dried blood, 50** |
| 9 | Acid phos., 120; muriate potash, 60; nitrate of soda, 280; dried blood, 50** |
| 10 | None |

Oats

- | | |
|----|---|
| 1 | None |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160 |
| 3 | Acid phos., 55; muriate potash, 50; nitrate soda, 160 |
| 4 | None |
| 5 | Yard manure, 2½ tons |
| 6 | Yard manure, 5 tons |
| 7 | None |
| 8 | Acid phos., 160; muriate potash, 100; nitrate soda, 320 |
| 9 | Acid phos., 110; muriate potash, 100; nitrate soda, 320 |
| 10 | None |

Corn

- | | |
|----|---|
| 1 | None |
| 2 | Acid phos., 160; muriate potash, 100; nitrate soda, 160 |
| 3 | Acid phos., 60; muriate potash, 30; nitrate soda, 160 |
| 4 | None |
| 5 | Yard manure, 2½ tons |
| 6 | Yard manure, 5 tons |
| 7 | None |
| 8 | Acid phos., 160; muriate potash, 100; nitrate soda, 320 |
| 9 | Acid phos., 120; muriate potash, 60; nitrate soda, 320 |
| 10 | None |

(South)

*120 pounds nitrate of soda plus 50 pounds dried blood is equivalent to 160 pounds nitrate of soda.

**280 pounds nitrate of soda plus 50 pounds dried blood is equivalent to 320 pounds nitrate of soda.

TABLE I: CROPS GROWN IN CONTINUOUS CULTURE. Yield and increase for 1910 and average annual yield for 17 years 1894-1910

Plot No.	Fertilizing materials Pounds per acre	1910				17 years, 1894 to 1910				Plot No.
		Yield		Increase		Yield		Increase		
		Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	Grain Bus.	Stover or straw Lbs.	
Corn										
1	None	9.32	1 240	.....	.....	21.46	1 429	.....	.....	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	25.54	2 100	18.26	937	41.70	2 312	21.85	948	2
3	Acid phosphate, 60; muriate potash, 30; nitrate soda, 160.	15.96	1 680	10.71	593	33.83	1 930	15.60	631	3
4	None	3.21	1 010	.....	.....	16.62	1 294	.....	.....	4
5	Yard manure, 2½ tons	12.68	1 530	9.15	523	27.97	1 748	11.76	529	5
6	None	23.11	1 930	21.25	927	37.66	2 112	21.86	909	6
7	None	4.18	1 000	.....	.....	15.37	1 188	.....	.....	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320.	29.04	2 440	25.60	1 533	46.42	2 380	32.05	1 244	8
9	Acid phosphate, 120; muriate potash, 60; nitrate soda, 320.	25.86	2 280	23.16	1 467	44.01	2 248	30.63	1 164	9
10	None	1.96	720	.....	.....	12.38	1 032	.....	.....	10
	Average unfertilized yield.....	4.67	992	.....	.....	16.87	1 237	.....	.....	
Oats										
1	None	21.24	980	15.76	1 412	21.06	794	20.35	1 085	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 160.	38.04	2 482	11.04	760	42.08	1 913	15.89	798	2
3	Acid phosphate, 60; muriate potash, 30; nitrate soda, 160.	34.37	1 920	.....	.....	38.30	1 658	.....	.....	3
4	None	24.37	1 250	6.59	435	23.08	1 245	7.85	321	4
5	Yard manure, 2½ tons	30.55	1 652	18.88	1 389	31.13	1 757	15.20	802	5
6	None	42.42	2 582	.....	.....	23.67	1 986	.....	.....	6
7	None	23.13	1 150	20.59	1 818	48.11	2 449	24.05	1 461	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 320.	43.74	2 950	21.66	2 070	46.46	2 328	22.06	1 339	8
9	Acid phosphate, 110; muriate potash, 100; nitrate soda, 320.	44.84	3 185	.....	.....	48.11	2 328	.....	.....	9
10	None	23.20	1 097	.....	.....	24.78	991	.....	.....	10
	Average unfertilized yield.....	23.73	1 119	.....	.....	23.45	921	.....	.....	
Wheat										
1	None	6.91	1 565	15.42	2 042	8.16	1 132	12.00	1 493	1
2	Acid phosphate, 160; muriate potash, 100; nitrate soda, 120; dried blood, 5.	22.17	3 490	12.42	1 429	20.29	2 585	7.76	895	2
3	Acid phosphate, 45; muriate potash, 30; nitrate soda, 120; dried blood, 5.	19.00	2 760	.....	.....	16.19	1 949	.....	.....	3
4	None	6.42	1 214	12.91	1 646	8.56	1 013	5.63	751	4
5	Yard manure, 2½ tons	19.58	2 865	18.41	2 615	14.17	1 773	9.83	1 274	5
6	None	25.33	3 840	.....	.....	18.36	2 302	.....	.....	6
7	None	7.17	1 230	21.33	2 853	8.51	1 089	14.97	1 892	7
8	Acid phosphate, 160; muriate potash, 100; nitrate soda, 200; dried blood, 50.	28.17	4 010	19.67	2 407	23.18	2 986	13.23	1 600	8
9	Acid phosphate, 90; muriate potash, 60; nitrate soda, 200; dried blood, 50.	26.17	3 490	.....	.....	21.13	2 549	.....	.....	9
10	None	6.17	1 010	.....	.....	7.61	904	.....	.....	10
	Average unfertilized yield.....	6.67	1 005	.....	.....	8.21	1 007	.....	.....	

THE 5-YEAR ROTATION

In this experiment corn, oats, wheat, clover and timothy are grown in succession on five tracts of land, A, B, C, D and E, containing 30 one-tenth acre plots each. Sections A and B of this test lie in Range VIII, south of the areas devoted to continuous cropping, while sections C, D and E occupy Range IX, near the east side of the farm.

The land was underdrained in 1893, and corn was grown that season on section C. The planting was delayed by the draining and the season proved unfavorable, so that the results of that season's work have not been included in the average. In 1894 wheat was harvested on section A, oats on section C and corn on section D. The clover and timothy followed the wheat on section A in 1895 and 1896, and the rotation has since been regularly followed.

Beginning with 1900, lime was applied to the west half of each plot in this rotation, fertilized and unfertilized alike, while the land was being prepared for corn, the lime being applied at the rate of one ton per acre of ground quicklime in 1900, 1901, 1902 and 1903, applied in the spring after plowing, and in the fall of 1903 for the crop of 1904. In 1905 the liming was changed to the east half, a ton of quicklime being used that spring, but in 1906 and 1907 ground limestone was used, at the rate of two tons per acre. No lime was applied in 1908. The table gives the average yield for the entire plot in each case, averaging the limed and unlimed halves.

In 1895 and 1896, and again in 1899, 1900 and 1901 the wheat in this test was injured by Hessian fly, the yield on the unfertilized land falling to a small fraction over one bushel per acre in 1896 and 1900.

Diagram II shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the five sections being arranged and treated exactly alike. Tables III and IV give the yields per acre for 1910 and for the average of the 17 years, and Table V shows the general results by periods.

DIAGRAM II: PLAN OF FERTILIZING IN 5-YEAR ROTATION

Plots one-tenth acre—Fertilizing materials in pounds per acre										
Plot No.	On corn			On oats			On wheat			
	Acid phosphate	Muriate of potash	Nitrate of soda	Acid phosphate	Muriate of potash	Nitrate of soda	Acid phosphate	Muriate of potash	Dried blood	Nitrate of soda
1	....	....	....	....	....	....	....	....	....	....
2	80	....	....	80	....	....	160	....	....	....
3	....	80	....	....	80	....	....	100	....	....
4	....	....	....	....	....	....	....	....	....	....
5	....	....	160	....	....	160	....	....	50	120
6	80	....	160	80	....	160	160	....	50	120
7	....	....	....	....	....	....	....	....	....	....
8	80	80	....	80	80	....	160	100	....	..
9	....	80	160	....	80	160	....	50	120	....
10	....	....	....	....	....	....	....	....	....	....
11	80	80	160	80	80	160	160	100	50	120
12	80	80	240	80	80	240	160	100	50	200
13	....	....	....	....	....	....	....	....	....	....
14	80	80	160	....	....	....	160	100	50	120
15	...	....	....	....	....	....	160	100	50	120
16	....	....	....	....	....	....	....	....	....	....
17	160	* 80	80	160	80	80	160	100	25	60
18	Barnyard manure, 8 tons on corn and wheat									
19	....	....	....	....	....	....	....	....	....	....
20	Barnyard manure, 4 tons on corn and wheat									
21	Same elements as 17, but nitrogen in oilmeal									
22	....	....	....	....	....	....	....	....	....	....
23	Same elements as 17, but nitrogen in dried blood									
24	Same elements as 17, but nitrogen in sulphate ammonia									
25	....	...	...	....	...	...	....	....	....	...
26	Same elements as 11, but phosphorus in bone meal									
27	Same elements as 11, but phosphorus in dissolved bone black*									
28	....	....	....	....	....	....	....	....	....	....
29	Same elements as 11, but phosphorus in basic slag									
30	Same elements as 17, but nitrogen in tankage									

*Previous to 1910. Since 1910 nitrogen in nitrate of lime and phosphorus in acid phosphate.

TABLE III: CROPS GROWN IN 5-YEAR ROTATION

Yield and increase per acre, 1910. Total fertilizing elements per acre for one rotation.

Plot No.	Fertilizing elements			Corn		Oats		Wheat		Hay		Plot No.
	Nitrogen Lbs.	Phosphorus Lbs.	Potassium Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	Clover Lbs.	Timothy Lbs.	
Yield per acre												
1	....	....	....	5.03	800	32.96	1,615	9.25	1,155	2,080	3,973	1
2	....	20	....	8.36	900	41.48	2,672	18.16	2,020	2,578	4,168	2
3	....	....	108	4.78	950	29.76	1,247	8.29	972	2,871	3,706	3
4	....	....	....	6.75	950	28.98	1,102	6.87	837	2,410	3,484	4
5	76	....	....	8.35	1,000	32.34	1,355	10.21	1,417	2,889	3,689	5
6	76	20	....	17.93	1,200	44.46	2,907	24.25	2,685	3,867	4,462	6
7	....	....	....	8.89	1,030	37.89	1,407	7.42	1,985	2,462	3,684	7
8	....	20	108	14.64	1,600	49.76	2,997	18.21	1,947	3,724	4,284	8
9	76	....	108	14.75	1,460	46.25	3,270	9.91	1,245	2,836	3,902	9
10	....	....	....	8.32	1,060	33.12	1,480	8.67	1,010	2,063	4,018	10
11	76	20	108	13.28	1,350	47.89	2,557	26.75	2,915	4,027	4,657	11
12	112	20	108	14.18	1,360	50.94	3,330	27.70	3,157	3,965	4,666	12
13	....	....	....	5.50	850	38.20	1,817	6.04	797	2,312	3,662	13
14	50	15	74	10.96	1,310	47.26	2,427	21.04	2,247	3,671	4,346	14
15	25	10	41	5.46	810	43.36	2,152	22.12	2,312	3,449	4,035	15
16	....	....	....	2.75	670	38.12	1,770	5.50	670	2,240	3,280	16
17	38	30	108	17.07	1,290	52.58	4,467	25.66	2,780	4,258	4,684	17
18	144	48	112	36.03	2,120	47.73	3,202	30.83	3,610	5,657	4,427	18
19	....	....	....	6.43	940	39.22	1,985	8.04	1,047	2,409	3,306	19
20	72	24	56	20.35	1,540	46.09	2,565	23.54	2,737	4,178	4,213	20
21	38	30	108	19.43	1,300	54.62	3,262	25.37	2,677	4,507	4,293	21
22	....	....	....	5.57	990	37.34	1,615	7.21	897	2,587	3,146	22
23	38	30	108	19.89	1,590	53.04	3,162	25.25	2,655	4,720	4,364	23
24	38	30	108	23.39	1,560	51.87	3,990	27.75	2,965	4,498	4,355	24
25	....	....	....	8.78	1,070	38.28	1,895	8.00	1,130	2,667	3,582	25
26	76	20	108	12.03	1,350	48.75	2,690	25.50	2,930	4,623	4,942	26
27	76	20	108	17.21	1,550	51.40	3,325	28.87	3,237	4,089	4,862	27
28	....	....	....	8.96	1,080	33.59	1,355	11.66	1,458	2,534	3,666	28
29	76	20	108	18.64	1,720	50.31	1,890	28.52	3,232	4,667	5,155	29
30	38	30	108	30.53	1,920	50.23	3,052	28.96	3,162	4,987	4,649	30
Average unfertilized yield				6.69	944	35.77	1,604	7.87	999	2,376	3,583	
Increase per acre												
2	....	20	....	2.76	50	9.85	1,228	9.70	971	388	358	2
3	....	....	108	-1.40	50	-55	-26	.63	29	571	59	3
5	76	....	....	.89	23	.39	151	3.16	531	462	138	5
6	76	20	....	9.75	197	9.54	1,602	17.01	1,749	1,422	845	6
8	....	20	108	5.94	560	13.46	1,566	10.37	954	1,395	479	8
9	76	....	108	6.24	410	11.54	1,814	1.66	243	640	-25	9
11	76	20	108	5.90	360	13.08	962	18.96	1,976	1,881	738	11
12	112	20	108	7.74	440	14.43	1,625	20.78	2,289	1,736	875	12
14	50	15	74	6.38	520	9.09	626	15.18	1,492	1,383	811	14
15	25	10	41	1.79	80	5.21	366	16.44	1,600	1,185	628	15
17	38	30	108	13.09	530	14.09	2,625	19.31	1,984	1,962	1,395	17
18	144	48	112	31.83	1,260	8.88	1,289	23.64	2,689	3,304	1,130	18
20	72	24	56	14.21	583	7.50	703	15.78	1,740	1,710	960	20
21	38	30	108	13.57	327	16.65	1,524	17.88	1,730	1,979	1,094	21
23	38	30	108	13.25	573	15.39	1,454	17.78	1,680	2,106	1,073	23
24	38	30	108	15.68	517	13.90	2,188	20.01	1,913	1,858	918	24
26	76	20	108	3.19	277	12.03	975	16.28	1,691	2,000	1,332	26
27	76	20	108	8.31	473	16.25	1,790	18.43	1,888	1,511	1,224	27
29	76	20	108	9.68	640	16.72	535	16.86	1,774	2,133	1,489	29
30	38	30	108	21.57	840	16.64	1,697	17.30	1,704	2,453	983	30

TABLE IV: CROPS GROWN IN 5-YEAR ROTATION

Average annual yield and increase per acre for the 17 years, 1894-1910

Plot No.	Fertilizing Elements			Corn		Oats		Wheat		Hay		Plot No.
	Nitrogen Lbs.	Phosphorus Lbs.	Potassium Lbs.	Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.	Clover Lbs.	Timothy Lbs.	
Yield per acre												
1	...	..	...	29.70	1,644	32.84	1,375	10.85	1,163	2,069	2,933	1
2	...	20	...	36.91	1,831	40.83	1,714	19.05	1,909	2,626	3,157	2
3	...	...	108	33.66	1,896	35.52	1,457	12.53	1,334	2,401	2,972	3
4	...	..	...	29.25	1,622	31.72	1,321	11.35	1,154	2,129	2,788	4
5	76	...	...	34.08	1,799	35.74	1,465	13.37	1,486	2,450	3,177	5
6	76	20	...	43.34	1,958	46.85	1,995	24.67	2,547	3,215	3,511	6
7	...	...	...	29.74	1,612	31.81	1,308	11.18	1,160	2,028	2,656	7
8	...	20	108	42.50	2,139	43.53	1,883	20.24	1,929	2,996	3,135	8
9	76	...	108	35.01	1,909	37.72	1,686	13.95	1,503	2,400	3,000	9
10	...	...	...	28.22	1,558	31.82	1,304	11.16	1,121	1,944	2,624	10
11	76	20	108	45.77	2,243	49.96	2,255	27.43	2,929	3,409	3,659	11
12	112	20	108	46.34	2,254	49.34	2,346	28.13	3,002	3,502	3,559	12
13	...	...	...	28.41	1,590	31.94	1,361	11.14	1,146	2,001	2,635	13
14	50	15	74	42.82	2,147	39.78	1,732	25.55	2,695	3,049	3,291	14
15	25	10	41	33.30	1,811	33.21	1,386	24.42	2,536	2,638	2,990	15
16	...	...	...	26.48	1,592	30.22	1,255	9.96	986	1,804	2,506	16
17	38	30	108	42.50	2,229	48.44	2,341	22.96	2,347	3,172	3,292	17
18	144	48	112	47.21	2,423	42.61	2,022	21.92	2,399	3,944	4,043	18
19	...	...	...	30.31	1,703	31.41	1,341	10.87	1,122	1,945	2,626	19
20	72	24	56	42.64	2,163	37.98	1,693	18.22	1,958	3,019	3,501	20
21	38	30	108	45.17	2,228	47.62	2,202	24.06	2,517	2,984	3,139	21
22	...	...	...	27.21	1,642	30.70	1,279	10.44	1,045	1,716	2,366	22
23	38	30	108	44.97	2,226	47.84	2,149	22.94	2,312	2,916	3,118	23
24	38	30	108	45.24	2,244	49.15	2,376	23.64	2,398	3,066	3,049	24
25	...	...	...	30.04	1,723	32.00	1,389	11.40	1,199	1,989	2,680	25
26	76	20	108	44.08	2,283	47.33	2,094	24.16	2,499	3,559	3,730	26
27	76	20	108	46.04	2,292	49.59	2,296	26.89	2,771	3,153	3,550	27
28	...	...	...	31.58	1,784	33.47	1,389	11.28	1,101	2,049	2,906	28
29	76	20	108	46.33	2,378	47.89	2,099	25.26	2,653	3,327	3,894	29
30	38	30	108	46.24	2,229	44.94	1,995	22.89	2,259	3,363	3,808	30
Average unfertilized yield				29.09	1,646	31.78	1,334	10.98	1,122	1,967	2,494	
Increase per acre												
2	...	20	...	7.36	195	8.40	357	8.03	749	536	272	2
3	...	...	108	4.25	268	3.45	118	1.35	178	291	135	3
5	76	...	...	4.67	180	3.99	148	2.07	331	355	433	5
6	76	20	...	13.76	342	15.07	683	13.42	1,389	1,153	811	6
8	...	20	108	13.27	545	11.72	576	9.00	782	996	489	8
9	76	...	108	6.28	333	5.90	380	2.78	369	434	366	9
11	76	20	108	17.49	674	18.10	932	16.29	1,800	1,446	1,031	11
12	112	20	108	17.99	675	17.43	1,004	16.98	1,864	1,520	927	12
14	50	15	74	15.07	556	8.41	406	14.81	1,602	1,114	699	14
15	25	10	41	7.43	255	3.46	170	14.07	1,497	796	442	15
17	38	30	108	17.91	600	17.82	1,057	12.70	1,316	1,321	746	17
18	144	48	112	21.65	756	11.01	702	11.35	1,323	2,046	1,457	18
20	72	24	56	13.36	480	6.80	373	7.49	861	1,150	961	20
21	38	30	108	16.93	565	16.61	880	13.48	1,446	1,192	686	21
23	38	30	108	16.81	557	16.71	833	12.18	1,215	1,108	647	23
24	38	30	108	16.14	548	17.58	1,024	12.56	1,250	1,168	473	24
26	76	20	108	13.52	540	14.84	705	12.80	1,333	1,550	974	26
27	76	20	108	14.97	527	16.61	907	15.58	1,638	1,125	719	27
29	76	20	108	14.75	594	14.42	709	13.98	1,552	1,278	988	29
30	38	30	108	14.66	444	11.47	605	11.61	1,158	1,314	902	30

TABLE V: TOTAL FERTILIZING MATERIALS AND THEIR COST, AND TOTAL AND NET VALUE OF INCREASE PRODUCED FOR 5-YEAR PERIODS AND FOR 17 YEARS, ALL CALCULATED FOR ONE ROTATION OF 5 YEARS

Plot No.	Fertilizing materials in pounds per acre for each rotation	Cost of fertilizers for each rotation	Average value of total increase per acre for each rotation				Net gain or loss (—) from fertilizers for each rotation				Plot No.
			First 5-years	Second 5-years	Third 5-years	17-year average Total	First 5-years	Second 5-years	Third 5-years	17-year average Net	
2	Acid phosphate, 320.	\$ 2.60	\$ 8.50	\$17.37	\$24.32	\$16.52	\$ 5.90	\$14.77	\$21.72	\$13.92	2
3	Muriate potash, 260.	6.50	5.19	4.67	9.17	6.22	-1.31	-1.83	2.67	-0.28	3
5	Nitrate soda, 440; dried blood, 50.	14.40	4.70	10.40	9.03	8.62	-9.70	-4.00	-5.37	-5.78	5
6	Acid phosphate, 320; nitrate soda, 440; dried blood, 50.	17.00	19.09	35.27	33.75	31.21	2.09	18.27	22.75	14.21	6
8	Acid phosphate, 320; muriate potash, 260.	9.10	14.40	24.37	33.51	24.41	5.30	15.27	24.41	15.09	8
9	Muriate potash, 260; nitrate soda, 440; dried blood, 50.	20.90	5.85	11.35	13.23	10.95	-15.05	-9.55	-6.67	-9.95	9
11	Acid phosphate, 320; muriate potash, 260; nit. soda, 440; dried blood, 50.	23.50	23.39	42.43	49.96	39.13	2.80	18.93	26.46	15.63	11
12	" " 240; " " 180; " " 120; " " 220.	50	26.15	45.53	48.24	39.68	-4.54	14.83	17.54	8.98	12
14	" " 240; " " 180; " " 120; " " 220.	50	21.37	32.91	27.13	30.49	5.32	15.86	21.28	14.44	14
15	" " 160; " " 100; " " 120; " " 220.	8.60	13.89	22.86	27.13	22.26	5.29	14.26	18.53	13.66	15
17	Yard manure, 16 tons.	17.60	15.73	36.61	46.28	34.21	-1.86	19.01	28.68	16.61	17
18	Yard manure, 8 tons.	?	13.82	34.24	55.94	38.21	?	?	?	?	18
20	Same elements as 17, but nitrogen in oilmeal.	17.60	13.02	21.28	35.36	23.77	?	?	?	?	20
21	" " 17, " " dried blood.	17.60	20.43	36.25	42.24	33.22	2.83	18.65	24.64	15.62	21
23	" " 17, " " sulphate ammonia.	17.60	19.09	34.57	39.28	31.36	1.49	16.77	21.68	19.78	23
24	" " 11, " " phosphorus in bonemeal.	23.50	20.70	32.77	38.71	31.44	3.10	14.77	21.11	13.84	24
26	" " 11, " " dissolved boneblack*.	23.50	20.89	36.17	42.55	33.41	-2.61	12.67	19.05	9.94	26
27	" " 11, " " basic slag.	23.50	19.86	39.38	42.08	34.14	-3.64	16.38	18.58	10.46	27
29	" " 11, " " nitrogen in tankage.	23.50	21.91	39.32	39.04	33.62	-1.59	15.82	15.54	10.12	29
30	" " 17, " " nitrogen in tankage.	**17.60	13.74	30.51	41.62	29.88	....	12.90	24.02	12.28	30

The nearest practicable approach to a common denominator for the various kinds of produce grown in this rotation is their market value, and in Table V the results of the test are arranged on this basis for three 5-year periods and for the entire 17 years, corn being rated at 40 cents per bushel, oats at 30 cents, wheat at 80 cents, hay at \$8.00 per ton, stover at \$3.00 and straw at \$2.00; valuations much below present prices for the grains, but not far from the average values during the period of the test.

The fertilizing materials are valued at a fraction over \$16.00 per ton for acid phosphate, 2½ cents per pound for muriate of potash and 3 cents per pound for nitrate of soda; and it is assumed that the cost per pound of the fertilizing elements will be practically the same in the other carriers used on Plots 21 to 30 inclusive. The table shows that the effectiveness of the fertilizers and manure has increased with each successive period, the greatest relative increase being shown by the manures. Taking the second part of the table, giving the net gain after deducting the cost of the fertilizers, it will be seen that eight of the fertilizer applications failed to produce sufficient increase to cover their cost; during the second period three, and during the third period two. Every complete fertilizer has been used with a profit since the first period, but when either nitrate of soda or muriate of potash has been used unaccompanied by some carrier of phosphorus there has been a loss in each period and in the average of the 16 years.

Nevertheless, both nitrogen and potassium are essential to the highest net profit, as shown by comparing Plot 2, receiving phosphorus only, with Plot 8, receiving potassium in addition, and Plot 11, receiving these with nitrogen.

The results of the comparison of different carriers of nitrogen and phosphorus have been discussed in Circular No. 93.

*Previous to 1910. Since 1910 nitrogen in nitrate of lime and phosphorus in acid phosphate.

**Since first period. Smaller application during first period.

THE POTATOES-WHEAT-CLOVER ROTATION

This experiment is located on the South Farm, southeast of the orchards, and contains three sections of 34 plots each. The south section (A) and about half of the middle section (B) had been in cultivation for an unknown period before the test began. The north part of section B and all of the north section (C) were cleared from the forest for the purposes of this test. The old land was tile drained in 1893 and the work was begun by planting Section A to potatoes in 1894. Wheat and clover followed in 1895 and 1896 and the rotation has been maintained regularly since.

The potato crops in this test have in some seasons been somewhat injured by blight, and in 1904 a dashing rain, coming just after the potatoes had been planted, washed much of the seed out of the ground. These difficulties have caused an irregular stand, and for this reason the attempt has been made to correct the yields on the basis of the average stand obtained on the unfertilized plots, but this method has not proved satisfactory and hence the actual yields are given in the table. In 1909 the potatoes were reduced to about one-third the average crop by a combined attack of white grub and *Fusarium* wilt, the latter causing the larger part of the injury. The crop was severely injured by wilt again in 1910.

In 1895 and 1896 the wheat in this test was severely injured by Hessian fly, but it escaped the attack of 1899 to 1901.

In 1900 the clover failed; attempts were made to grow crimson clover and soybeans in its stead, but there was failure in securing a stand of these crops also, so that it has been necessary to omit that season from the calculations. In 1905 continuous rains prevented harvesting the clover until very late, and caused the fertilized plots to lodge, so that these plots weighed less than those not fertilized, though earlier in the season they had shown a distinctly stronger growth. As there was no way by which the yields could be corrected and as it seemed desirable to include the crop in the general average because of its effect on the average unfertilized yield it has been so included, although the doing so slightly reduces the apparent average effect from the fertilizers.

Diagram III shows the arrangement of plots and plan of fertilizing one of the sections in this experiment, the three sections being arranged and treated alike. Tables VI and VII give the yield per acre for 1910 and for the 17 years, 1894-1910.

Fertilizing materials in pounds per acre

[illegible]

CROPS IN 3-YEAR ROTATION OF POTATOES, WHEAT AND CLOVER

TABLE VI: Yield per acre, 1910, and average for 17 years, 1894-1910

Fertilizing elements for each rotation

Plot No.	Fertilizing elements			Potatoes		Wheat				Clover		Plot No.
	Nitro- gen Lbs.	Phos- phorus Lbs.	Potas- sium Lbs.	1910 Bus. (actual)	17-yr. av. Bus.	1910		16-year av.		1910 Lbs.	15-yr. av. Lbs.	
						Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.			
1	...	..	...	70.25	154.43	26.33	3,473	30.84	3,225	5,298	4,334	1
2	...	20	...	69.08	167.97	35.44	4,141	36.54	3,856	5,742	4,574	2
3	...	..	83	96.67	167.60	21.67	2,478	32.41	3,061	5,351	4,215	3
4	...	..	...	75.42	158.47	20.99	2,519	30.51	3,026	5,031	3,929	4
5	38	..	...	80.50	163.16	21.01	2,996	30.77	3,261	5,191	4,207	5
6	38	20	...	87.92	170.01	30.97	3,969	36.51	3,925	5,209	4,352	6
7	...	..	...	77.00	145.44	22.09	2,975	28.64	2,845	4,231	3,813	7
8	...	20	83	102.05	178.42	38.62	4,282	36.48	3,445	5,280	4,151	8
9	38	..	83	99.92	162.71	25.00	3,040	34.56	3,304	5,138	4,338	9
10	...	..	...	66.33	147.72	23.54	2,887	29.89	2,834	4,942	3,740	10
11	38	20	83	103.25	173.57	34.12	4,452	38.64	3,877	5,778	4,275	11
12	50	20	83	107.42	180.53	33.17	4,370	38.38	4,008	5,849	4,442	12
13	...	..	...	67.83	146.24	20.96	2,782	29.15	2,777	5,084	3,879	13
14	50	30	124	108.75	181.88	33.33	4,220	38.31	3,977	5,831	4,430	14
15	50	30	124	100.75	177.54	33.54	3,947	37.09	3,658	5,671	4,400	15
16	...	..	...	67.58	137.06	22.25	3,025	27.79	2,581	4,356	3,569	16
17	36	12	28	89.75	150.89	29.21	3,387	32.02	3,180	5,013	4,208	17
18	72	24	56	100.50	157.14	32.71	4,157	33.29	3,301	5,511	4,614	18
19	...	..	...	68.50	135.28	19.62	2,282	25.01	2,453	4,302	3,332	19
20	25	20	83	102.58	177.75	35.33	4,120	34.69	3,465	5,404	4,191	20
21	25	20	83	94.33	169.13	35.58	4,125	34.83	3,367	5,120	3,792	21
22	...	..	...	62.50	137.30	17.58	2,385	24.60	2,285	3,822	3,359	22
23	25	20	83	103.25	166.02	35.37	4,157	35.45	3,418	4,604	3,819	23
24	25	20	83	104.25	172.82	36.75	4,095	35.52	3,346	4,729	3,817	24
25	...	..	...	72.17	137.12	21.83	2,710	25.28	2,401	4,089	3,413	25
26	38	20	83	107.50	167.37	31.16	3,590	35.81	3,461	5,049	4,188	26
27	38	20	83	112.83	173.32	35.50	4,370	37.24	3,786	5,156	4,008	27
28	...	..	...	74.42	139.51	26.37	3,237	25.62	2,526	3,964	3,532	28
29	38	20	83	108.83	171.85	35.50	4,490	37.66	3,817	4,747	4,429	29
30	72	24	56	107.75	182.96	34.00	4,300	32.63	3,229	5,084	4,361	30
31	...	..	...	71.83	144.33	25.37	3,337	25.42	2,522	4,053	3,444	31
32	144	48	112	110.58	188.61	34.12	4,632	38.74	4,036	5,973	5,043	32
33	25	20	83	99.17	173.39	36.29	3,612	38.83	3,619	5,298	4,077	33
34	...	..	...	87.17	138.19	24.33	3,460	27.27	2,629	4,658	3,505	34
Average unfertilized yield				71.75	143.22	22.27	2,919	27.29	2,660	4,486	3,664	

TABLE VII: Increase per acre, 1910, and annual average for 17 years, 1894-1910
Cost of fertilizer for 1 rotation and 17-year average value of increase for each rotation

Plot No.	Potatoes		Wheat				Clover		Cost of ferti- lizer	Value of increase for one rotation		Plot No.
	1910 Bus. (actual)	17-yr. av. Bus.	1910		16-year av.		1910 Lbs.	15-yr. av. Lbs.		Total	Net	
			Grain Bus.	Straw Lbs.	Grain Bus.	Straw Lbs.*						
2	-2.89	12.20	10.89	986	5.83	696	533	376	\$2.60	\$11.74	9.14	2
3	22.97	10.48	-1.10	-359	1.79	-31	231	151	5.00	6.20	1.20	3
5	4.55	9.03	-0.35	342	.88	295	427	316	7.20	5.87	-1.33	5
6	11.45	20.23	9.25	1,179	7.24	1,020	711	500	9.80	16.90	7.10	6
8	29.06	32.22	16.05	1,370	7.42	603	812	362	7.60	20.90	13.30	8
9	30.03	15.74	1.94	140	5.08	466	433	575	12.20	13.12	.92	9
11	36.42	26.35	11.44	1,600	8.99	1,062	789	488	14.80	20.74	5.94	11
12	40.09	38.78	11.35	1,553	8.98	1,212	812	649	19.60	24.50	4.90	12
14	41.00	38.70	11.94	1,357	9.61	1,266	990	647	21.00	27.02	6.02	14
15	33.09	37.42	11.72	1,003	8.86	1,012	1,072	714	21.00	25.92	4.92	15
17	21.86	16.05	7.84	610	5.15	643	675	705	?	14.00	?	17
18	32.31	22.64	12.21	1,627	7.29	806	1,191	1,195	?	20.47	?	18
20	36.08	41.81	16.39	1,804	9.82	1,068	1,262	849	12.40	29.04	16.64	20
21	29.83	32.51	17.32	1,774	10.09	1,026	1,138	442	12.40	23.87	11.47	21
23	37.53	28.75	16.37	1,664	10.62	1,095	693	442	12.40	22.86	10.46	23
24	35.31	35.64	16.34	1,493	10.46	984	729	422	12.40	25.29	12.89	24
26	34.58	29.45	7.82	704	10.42	1,018	1,002	735	14.80	24.08	9.28	26
27	39.16	34.61	10.64	1,309	11.73	1,302	1,150	516	14.80	26.59	11.79	27
29	35.27	30.74	9.46	1,220	12.10	1,292	753	922	14.80	26.95	12.15	29
30	35.06	40.24	8.30	996	7.15	706	1,061	879	?	26.04	?	30
32	33.64	44.93	9.10	1,254	10.86	1,292	1,718	593	?	34.27	?	32
33	17.11	32.48	11.61	193	11.25	933	842	593	12.40	25.29	12.89	33

BARNYARD MANURE TEST

COMPARISON OF YARD WITH FRESH MANURE

THE REINFORCEMENT OF MANURE

This experiment was begun in 1897 for the purpose of comparing manure which has lain for some months in an open barnyard with that taken directly from the stable to the field, and of studying the effect of treating the manure with several absorbent or reinforcing materials.

In this investigation a lot of manure has been taken from the open barnyard, where it has been accumulating during the winter, and divided into four parcels. With one parcel is mixed the finely ground, phosphatic rock, known as floats, from which acid phosphate is made by mixing it with sulphuric acid; with another parcel acid phosphate is mixed; with a third, the crude potash salt, known as kainit, and with a fourth, land plaster or gypsum; the reinforcing materials being used at the uniform rate of 40 pounds per ton of manure. At the same time manure taken from box stalls, where it has accumulated under the feet of animals kept continuously in their stalls, is divided into similar parcels and treated with like quantities of the same materials.

After a few weeks the manure thus treated, together with two lots of untreated manure, one taken from the yard and one from the stable, is spread upon clover sod at the rate of eight tons per acre and plowed under for corn, the corn being followed by wheat and clover in a 3-year rotation. During the first three seasons soybeans were grown, because of clover failure, and were plowed under.

Three tracts of land, A, B and C, are included in the test, each crop being grown every season. The arrangement of these tracts and the plan of fertilizing are shown in Diagram IV, and the results are given in Tables VIII and IX.

**DIAGRAM IV: ARRANGEMENT OF PLOTS AND PLAN OF FERTILIZING IN
EXPERIMENTS WITH MANURE**

PLOTS ONE-SIXTEENTH ACRE

SECTION A	11	Nothing	1	Nothing
	12	Yard manure and gypsum	2	Yard manure and floats
	13	Stall manure and gypsum	3	Stall manure and floats
	14	Nothing	4	Nothing
	15	Yard manure, untreated	5	Yard manure and acid phos.
	16	Stall manure, untreated	6	Stall manure and acid phos.
	17	Nothing	7	Nothing
	18	Chemical fertilizer	8	Yard manure and kainit
	19	Chemical fertilizer	9	Stall manure and kainit
	20	Nothing	10	Nothing
SECTION B	11	Nothing	1	Nothing
	12	Yard manure and gypsum	2	Yard manure and floats
	13	Stall manure and gypsum	3	Stall manure and floats
	14	Nothing	4	Nothing
	15	Yard manure, untreated	5	Yard manure and acid phos.
	16	Stall manure, untreated	6	Stall manure and acid phos.
	17	Nothing	7	Nothing
	18	Chemical fertilizer	8	Yard manure and kainit
	19	Chemical fertilizer	9	Stall manure and kainit
	20	Nothing	10	Nothing
SECTION C	11	Nothing	1	Nothing
	12	Yard manure and gypsum	2	Yard manure and floats
	13	Stall manure and gypsum	3	Stall manure and floats
	14	Nothing	4	Nothing
	15	Yard manure, untreated	5	Yard manure and acid phos.
	16	Stall manure, untreated	6	Stall manure and acid phos.
	17	Nothing	7	Nothing
	18	Chemical fertilizer	8	Yard manure and kainit
	19	Chemical fertilizer	9	Stall manure and kainit
	20	Nothing	10	Nothing

NORTH

TABLE VIII: BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION
Average yield per acre 1910 and 14 years 1897-1910

Plot No.	Manure and treatment	1910						14 years, 1897-1910						Plot No.	
		Corn, Sec. C			Wheat, Sec. A			Clover			Corn 13* crops				Hay 10 yrs. Lbs.
		Grain Bus.	Stover Lbs.	Yield per acre	Grain Bus.	Straw Lbs.	Sec. B Lbs.	Grain Bus.	Stover Lbs.	Straw Lbs.	Grain Bus.	Stover Lbs.	Straw Lbs.		
1	None	29.96	2,336	14.27	2,248	3,248	3,248	36.60	2,231	12.93	1,573	2,231	1,573	2,828	
2	Yard manure and floats	48.34	3,008	22.80	3,160	4,523	4,523	58.56	3,290	25.40	2,765	3,290	2,765	4,202	
3	Stall manure and floats	48.34	3,456	25.20	3,448	4,935	4,935	62.16	3,557	26.86	2,967	3,557	2,967	4,784	
4	None	21.26	1,872	12.87	1,996	2,901	2,901	30.28	1,998	11.45	1,352	1,998	1,352	2,154	
5	Yard manure and acid phosphate	52.46	2,944	24.20	3,188	4,864	4,864	59.67	3,250	26.07	2,819	3,250	2,819	4,052	
6	Stall manure and acid phosphate	55.77	3,320	26.73	3,788	5,461	5,461	63.71	3,474	26.76	2,981	3,474	2,981	4,764	
7	None	20.97	1,932	9.67	1,676	2,816	2,816	30.07	1,969	10.06	1,255	1,969	1,255	2,113	
8	Yard manure and kainit	44.46	3,361	25.40	3,484	5,384	5,384	53.84	3,169	21.84	2,482	3,169	2,482	3,405	
9	Stall manure and kainit	45.89	3,440	26.13	3,536	5,495	5,495	58.97	3,491	23.54	2,783	3,491	2,783	4,215	
10	None	16.23	1,648	12.60	2,012	3,527	3,527	31.61	1,976	10.85	1,318	1,976	1,318	2,378	
11	Yard manure and gypsum	34.06	2,500	14.53	2,216	3,484	3,484	36.62	2,350	13.91	1,719	2,350	1,719	3,063	
12	Yard manure and gypsum	55.43	3,424	24.40	3,464	5,110	5,110	57.78	3,368	25.19	2,759	3,368	2,759	3,681	
13	Stall manure and gypsum	47.60	3,296	24.40	3,400	4,352	4,352	59.65	3,530	24.09	2,714	3,530	2,714	3,737	
14	None	18.34	1,952	10.13	1,696	3,541	3,541	30.55	2,002	10.72	1,253	2,002	1,253	2,165	
15	Yard manure, untreated	44.11	2,720	23.20	3,136	4,252	4,252	50.63	2,873	20.09	2,260	2,873	2,260	3,060	
16	Stall manure, untreated	52.06	3,520	25.07	3,600	5,404	5,404	57.69	3,321	21.63	2,445	3,321	2,445	3,789	
17	None	27.80	2,626	9.13	1,676	3,840	3,840	35.88	2,328	11.17	1,379	2,328	1,379	2,437	
18	Chemical fertilizer ¹	43.94	2,912	20.40	2,728	3,684	3,684	43.18	2,612	14.70	1,718	2,612	1,718	3,004	
19	Chemical fertilizer ²	28.23	2,496	17.13	2,460	3,666	3,666	43.13	2,439	15.60	1,888	2,439	1,888	3,178	
20	None	16.40	1,824	12.60	1,932	3,812	3,812	32.73	2,009	11.50	1,347	2,009	1,347	2,608	
Average unfertilized yield		23.13	2,096	11.97	1,956	3,396	3,396	33.04	2,107	11.53	1,373	2,107	1,373	2,435	

*Excluding crop of 1909, which was so injured by grub worms that no comparison is possible.

¹ Acid phosphate, 80 lbs.; muriate of potash, 80 lbs.; nitrate of soda, 160 lbs.

² Acid phosphate, 80 lbs.; muriate of potash, 10 lbs.; tankage (7-30), 100 lbs.

TABLE IX: BARNYARD MANURE ON CROPS GROWN IN 3-YEAR ROTATION

Average annual increase and its value (excluding corn crop of 1909)

Plot No.	Manure and treatment	Average annual increase per acre					Cost of treatment per acre	Value of increase*	
		Corn 13 crops		Wheat 13 crops		Hay 10 crops		Total per acre	Net per ton of manure
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.				
2	Yard manure and floats.....	24.08	1,136	12.98	1,266	1,605	\$1.40	\$29.40	\$3.50
3	Stall manure and floats.....	29.78	1,481	14.97	1,541	2,418	1.40	37.32	4.49
5	Yard manure and acid phos...	29.46	1,262	15.08	1,499	1,925	2.40	34.94	4.07
6	Stall manure and acid phos...	33.57	1,495	16.17	1,694	2,644	2.40	40.87	4.81
8	Yard manure and kainit.....	23.26	1,198	11.42	1,206	1,203	2.70	26.25	2.94
9	Stall manure and kainit.....	27.88	1,517	12.91	1,486	1,924	2.70	32.94	3.78
12	Yard manure and gypsum...	23.18	1,134	11.55	1,195	928	1.00	25.12	3.02
13	Stall manure and gypsum...	27.08	1,412	12.31	1,306	1,273	1.00	29.19	3.52
15	Yard manure untreated.....	18.30	762	9.99	965	804	....	20.63	2.58
16	Stall manure untreated.....	23.59	1,102	10.62	1,107	1,427	....	26.54	3.32
18	Chemical fertilizer ¹	8.35	390	3.71	350	509	7.45	9.28	....
19	Chemical fertilizer ²	9.35	343	4.78	525	626	2.30	11.09	...

¹ Acid phosphate, 80 lbs; muriate of potash, 80 lbs; nitrate of soda, 160 lbs.² Acid phosphate, 80 lbs; muriate of potash, 10 lbs; tankage, (7-30) 100 lbs.

* See page 11 for valuations.

In all these experiments the increase has been computed on the assumption that changes in the natural fertility of the soil are likely to be progressive; that is, that if the yields of Plots 1 and 4, unfertilized, were 30 and 33 bushels, respectively, those of Plots 2 and 3 would probably have been 31 and 32 bushels, had no fertilizers been applied. As a rule the outcome of the work has justified this assumption, but in the manure test the yields of Plots 1 and 11, Section C, have been so much larger than those of the other unfertilized plots of the series that the question has been raised whether these plots (which are continuous) may not have been located on a strip of land—such as an old fence row—which has not been so depleted of its fertility under previous management as that covered by the adjoining plots.

In Table X the average total yields obtained on the plots treated with floats and acid phosphate are arranged by sections:

TABLE X: Average total yields in plots treated with floats and acid phosphate, arranged by sections

Crop and Section*		Yard manure		Stall manure	
		With floats	With acid phosphate	With floats	With acid phosphate
Corn, bus:	A	54.85	50.99	57.86	58.21
	B	67.50	70.04	71.64	70.71
	C	54.39	58.31	58.04	62.52
Wheat, bus:	A	22.05	23.22	29.89	24.95
	B	30.47	31.80	31.53	29.67
	C	24.50	23.88	24.65	26.15
Hay, lbs:	A	4,610	4,072	5,262	4,835
	B	3,720	3,836	4,030	4,007
	C	4,437	4,821	5,312	5,703

*The differences in yield of the different sections are chiefly due to seasonal differences, not to variation of soil.

In 10 of the 18 comparisons given in Table X the total yields on the plots treated with acid phosphate have exceeded those on the plots treated with floats. The general average of all the sections is shown below:

AVERAGE TOTAL YIELD PER ACRE

	Corn Bus.	Wheat Bus.	Hay Lbs.
Yard manure and floats.....	58.56	25.40	4,202
Yard manure and acid phosphate.....	59.67	26.07	4,052
Stall manure and floats.....	62.16	26.86	4,784
Stall manure and acid phosphate.....	63.71	26.76	4,764

LIME AND FLOATS TEST

This experiment was begun in 1905 in a 3-year rotation of corn, oats and clover, for the purpose of comparing the effect of different forms of lime and of obtaining further experience in the use of floats.

The land had been under the regular rotative cropping of the farm since its occupation by the Station, and for a considerable period before, and was in good condition. Twelve tons of manure per acre had been plowed under for corn 1904. Three sections of 26 plots each are included in the test, the plots containing one-twentieth acre each.

For the crops of 1905 Section A (north end) was manured at the rate of 6 tons per acre only, because of the recent application above mentioned, limed and fertilized and planted in corn. Section B was sown to soybeans instead of clover, the beans to be followed by rye in the fall and corn in 1906. Section C (south end) was limed and fertilized without manure and sown to oats and clover. Thenceforth the manure, lime and fertilizers have all been applied to the corn crops, the manure being plowed under and the lime and fertilizers applied on the surface. The oats and clover receive no treatment.

The clover seeding failed in 1906, 1908 and 1909, and soybeans were sown instead and harvested as hay. As the soybean suffers less from lack of lime than clover the result has been a smaller apparent effect from the lime than might otherwise have been found.

The plan of treatment and average results of the work for the first six years are given in Table XI.

It is too early to attempt to draw conclusions from this experiment. For a soil which is capable of producing a 6-year average of 57 bushels of corn, followed by 52 bushels of oats and 2 1-2 tons of clover hay without any treatment the chief problem is that of maintaining this rate of yield.

So far as present results may be accepted as a guide they support other experiments of the Station in indicating that ground limestone and floats should be used only as reenforcements of manure or fertilizer and never as substitutes.

TABLE XI: CROPS GROWN IN 3-YEAR ROTATION UNDER TREATMENT WITH MANURE, LIME AND FLOATS
AVERAGE YIELD AND INCREASE FOR 6 YEARS, 1905-1910 INCLUSIVE

Plot No.	Treatment (Lime, manure etc., per acre applied to corn only)	Yield per acre					Increase per acre					Total value of increase	Cost of lime and fertilizer	Net gain or loss (-) per acre	Gain per ton of manure	Plot No.
		Corn, 6 years		Oats, 6 years		Hay 5 yrs.	Corn 6, years		Oats, 6 years		Hay 5 yrs.					
		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.		Grain Bus.	Stover Lbs.	Grain Bus.	Straw Lbs.						
1	None.	58.42	3,233	49.30	2,846	5,120	12.21	551	4.75	214	449	\$9.14	\$1.50	\$	0.95	1
2	Caustic lime, 500 lbs.; manure, 8 tons.	70.52	3,813	55.38	2,984	5,622	14.08	612	3.71	285	620	10.42	3.00	7.64	0.93	2
3	Caustic lime, 1,000 lbs.; manure, 8 tons.	72.27	3,903	55.68	2,978	5,829										3
4	None.	58.07	3,320	53.30	2,617	5,281										4
5	Caustic lime, 2,000 lbs.; manure, 8 tons.	74.34	4,060	56.57	3,042	6,481	15.58	734	3.17	435	1,137	13.26	6.00	7.26	0.91	5
6	Ground limestone, 1,780 lbs.; manure, 8 tons	74.44	3,937	57.56	2,958	6,162	14.99	606	4.05	361	757	11.51	2.70	8.81	1.10	6
7	None.	60.14	3,337	53.60	2,587	5,467										7
8	Air slaked lime, 1,780 lbs.; manure, 8 tons	73.25	4,033	57.03	3,078	6,158	13.07	731	4.29	542	803	11.36	5.30	6.06	0.76	8
9	Hydrated lime, 1,320 lbs.; manure, 8 tons.	73.09	4,017	56.89	3,049	5,991	12.88	709	5.02	564	748	11.27	4.00	7.27	0.91	9
10	None.	60.25	3,293	51.01	2,434	5,131										10
11	Gypsum, 1,000 lbs.; manure, 8 tons.	68.56	3,730	56.64	2,657	5,108	9.54	488	5.28	270	89	6.75	3.00	3.75	0.47	11
12	Floats, 1,000 lbs.; manure, 8 tons.	69.57	3,730	57.97	2,765	5,293	11.78	539	6.25	425	385	9.36	4.50	4.86	0.61	12
13	None.	56.56	3,140	52.08	2,293	4,797										13
14	Caustic lime, 1,000 lbs.	61.33	3,557	53.84	2,497	5,088	5.09	417	1.42	211	367	4.66	3.00	1.66	...	14
15	Caustic lime, 1,000 lbs.	58.29	3,157	51.87	2,307	4,865	2.36	17	-.88	28	219	1.60	2.70	-1.10	...	15
16	Ground limestone, 1,780 lbs.	55.61	3,140	53.69	2,271	4,571									...	16
17	{ Caustic lime, 1,000 lbs.; acid phos., 320 } { lbs.; muriate potash, 40 lbs. } { Caustic lime, 1,000 lbs.; floats, 320 lbs.; } { muriate potash, 40 lbs. }	70.64	3,770	56.01	2,457	5,594	14.05	603	3.05	169	935	11.34	6.60	4.70	...	17
18	None.	68.60	3,737	53.99	2,339	5,575	11.02	543	1.16	33	829	8.92	5.45	3.47	...	18
19	Acid phosphate, 320 lbs.	58.56	3,220	52.69	2,324	4,834									...	19
20	Acid phos., 320 lbs.	65.22	3,477	52.16	2,301	5,154	6.84	287	-.20	16	271	4.32	2.60	1.70	...	20
21	Acid phos., 320 lbs.; mur. of potash 40 lbs.	69.20	3,750	54.04	2,441	5,396	10.99	590	2.00	196	463	7.92	3.60	4.32	...	21
22	None.	58.03	3,130	51.72	2,205	4,982									...	22
23	Floats, 320 lbs.	59.67	3,127	52.00	2,252	4,941	3.09	51	.74	55	81	1.91	1.45	0.46	...	23
24	Floats, 320 lbs.; muriate of potash, 40 lbs.	61.48	3,407	50.79	2,164	4,741	6.33	386	...	-26	3	3.10	2.45	0.65	...	24
25	None.	53.67	2,967	50.33	2,182	4,616									...	25
26	{ Floats, 320 lbs.; mur. of potash, 40 lbs.; } { dried blood, 100 lbs.* }	58.87	3,347	52.58	2,595	4,702	5.20	380	.57	-8	86	3.15	3.85	-0.70	...	26
	Average unfertilized yield	57.70	3,198	51.90	2,418	4,977										

*Beginning with 1909 Plot 26 receives manure only

*Beginning with 1909 Plot 26 receives manure only

Ohio Agricultural Experiment Station

CIRCULAR No. 115

WOOSTER, OHIO, AUGUST 14, 1911

THE CHINCH BUG

Blissus leucopterus Say

By H. A. GOSSARD

For several summers Ohio has suffered to a considerable extent from drouth. Warm dry weather is favorable to chinch bug increase and several counties in the west central and northwestern parts of the State reported some damage last year. The present year has seen an extension of the infested territory and the damage in the aggregate has amounted to a large sum, though the outbreak can hardly be said to compare in severity with the worst ones known to the more western states. The light crop of wheat obtained in many fields this season was more largely due to this insect than to any other cause, though the Hessian Fly did considerable mischief in some neighborhoods, sometimes adding to the damage wrought by the chinch bug. In lesser degree, the jointworm contributed to the sum total of injury.



Outside rows of corn wilted and fallen from chinch bug attack.
Photo taken about three weeks after wheat harvest.

GEOGRAPHY OF THE OUTBREAK

If the number of reports of chinch bug damage received at the Station, reinforced by inferences from statements in the letters and by some limited observations by entomological employes, can be accepted as an index to the amount of damage wrought, we conclude that the following counties are quite badly infested: Williams, Defiance, Paulding, Van Wert, Darke, Miami, Shelby, Auglaize, Hancock, Hardin, Wyandot, Seneca, Crawford, Morrow, Richland, Knox, Huron, Delaware, Ashland, Wayne, Wood, Champaign, Union, Marion, Logan; and to a lesser degree, the following: Franklin, Licking, Holmes, Stark, Jefferson, Lorain, Erie, Sandusky, Fulton, Henry, Putnam, Clark, Greene, Montgomery, Preble, Mercer and Medina. It is quite probable that some of the counties in the second list are as badly infested as the worst, and considerable damage has probably occurred in some counties from which we have received no reports. If weather conditions this fall and next spring should chance to favor the increase of the insect, it seems likely that nearly the whole state will be involved and the loss may be far greater than it has been the past two seasons.

DESCRIPTION

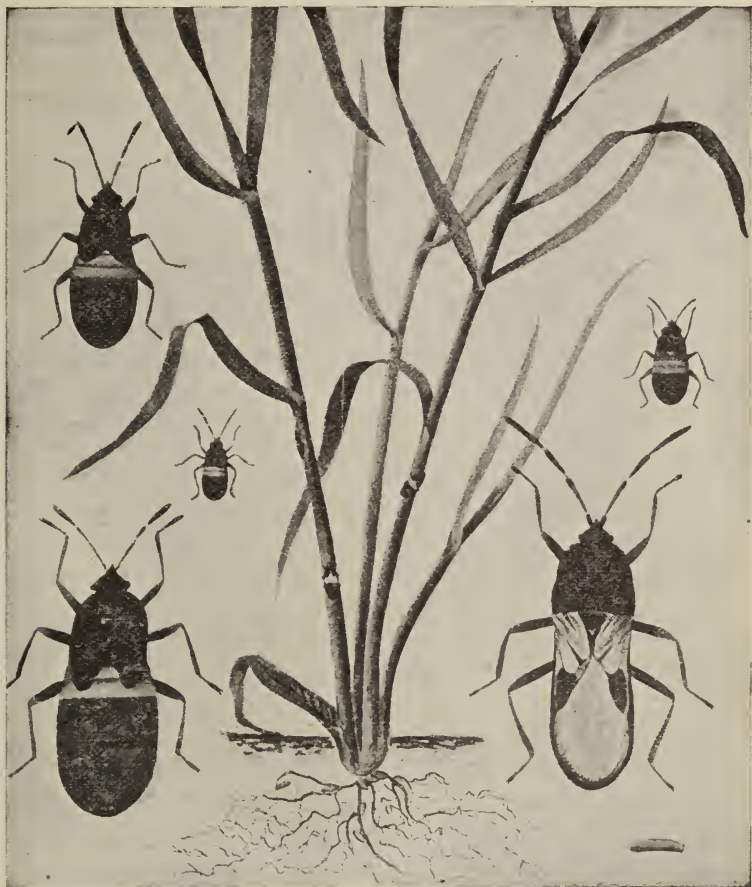
The egg is .03 inch long and elongate-oval in shape, with one end as if it were sawn flat across, and four minute projections or tubercles on the flattened end. When newly laid, the egg is whitish and partially transparent, but it shortly becomes yellowish and later distinctly reddish as the hatching time approaches.

The newly hatched *larva* is pale yellow in color, but in a short time becomes bright blood-red. After the first moult, the red becomes bright vermillion, and a pale yellowish band crosses the middle of the body transversely. The head and prothorax are rather dusky in this stage and, after the second moult, the anterior part of the body becomes blackish or dusky, and the abdomen a much duller red, the pale transverse band still remaining distinct. The wing-pads make their appearance at this time.

After the third moult, the nymph or pupa appears. This is dusky gray in color, the fore parts of the body being nearly black. The wing-pads nearly cover the pale abdominal band which still extends transversely across the body.

There are two forms of the adult or matured bugs, one having wings sufficiently long to cover nearly the whole of the abdomen, the other with much shorter wings covering hardly more than half of the abdomen and, in some specimens, less than half. The general body color of both forms is the same, black, and the insect is somewhat

hairy, the hairs also being black, while the underwings are white. The upper wings are whitish, each being ornamented with a black spot of triangular outline. The length is nearly .15 inch. The long-winged form is the more common one in Ohio, the short-winged type being rather partial to timothy, meadow and forage grasses.



The five stages after hatching, the graded sizes showing the youngest to the mature insect. Eggs shown on the roots; much enlarged egg in lower right-hand corner. (After Forbes.)

LIFE HISTORY AND NUMBER OF BROODS

Each female is capable of laying any number of eggs up to 500 or more, with the average probably less than one-half this number. The period of egg-laying for the individual lasts from ten days to three weeks, and for the brood from five to six weeks. The eggs hatch in from twelve to twenty-two days, and the young require forty days or more to become adults after issuing from the eggs. It thus requires two months, or a few days less, to pass from the newly laid egg to the adult condition.

The eggs are laid on the roots of the plants on which the bugs are feeding, at or just below the surface of the ground; or they may



Side view of adult much enlarged; shows hairiness of body

be laid on the surface about the bases of the plants, or in the leaf-sheaths of grasses; in short, in almost any place where the surroundings are cool and damp. For most of Ohio there are two broods, the first beginning to appear in late May or early June, and terminating in late July. The second brood begins to appear in early August and is matured in the latter part of September and early October. In some seasons, and possibly in all, there appears to be only the first brood in northeastern Ohio.

HABITS

The newly hatched larvae feed on the roots of their host plants, largely underground and out of sight. If very numerous they may congregate about the bases of the plants above ground. When the wheat plants are killed at harvest, the young migrate at once in search of other sustenance and, when thus collected together in great numbers, they may blacken the entire surface of large plants, such as corn nearly grown. So insidious is their work in wheat that their presence is often unrecognized until after the harvest, when the vast hordes of insects marching into cornfields attract the farmer's notice for the first time. Timothy meadows may be well-nigh killed without the owners suspecting why they are dying. A very careful examination of the roots of timothy is needed to detect the presence of the insects, even where they are very plentiful. The second brood of bugs rarely gain attention, because they are developing under-ground on the roots of corn, foxtail, millet and other plants.



Moulting; adult bug emerging from pupal skin

Since excessive chinch bug development and dry weather are nearly always coincident in point of time, and the bugs are so concealed from sight, the damage they do is often, perhaps generally, ascribed to the weather without investigation.

The insects cluster about the bases of the corn stalks and may prevent the development of the brace roots which keep the stalk upright, and thus in the latter part of summer, many stalks may be leveled to the ground by high winds and fail to properly mature their ears. The short-winged form is generally found in timothy meadows and on grassy land, while the cereal grains are damaged chiefly by the long-winged form.



Photograph showing nymphs and one adult just escaped from pupal skin

In late fall, about the time of Indian summer, the insects commence choosing their winter quarters, collecting in great numbers among the weeds, grass and leaves that are found along roadsides and in angles of worm fences, among the leaves lying in brush patches and woodlots, beneath shocks of corn fodder, under newly spread manure and straw, under bits of board and stones, and beneath all sorts of similar protection. They will be quiet until spring, beginning to fly about in April, unless cold weather is prolonged until late. The appearance of the insects will be scattered over several weeks and the first eggs may be laid before all of the bugs have left their winter shelters. In southern Ohio, the earliest eggs will doubtless be laid in late April in early seasons. The insects fly considerable distances and generally settle in wheat fields, the plants being of suitable age to be inviting. The bugs which later escape from their hibernating quarters, may find corn, oats or barley reaching an inviting state of development.



Where the chinch bugs delight to hide in winter. A worm-fence row, overgrown with brush, grass and weeds

These insects are sucking creatures and obtain their entire nourishment by sucking out the sap of the plants preferred by them for food.



Chinch bugs clustered at the base of corn stalks just after wheat harvest

FOOD PLANTS AND CROP PREFERENCES

Wheat is injured more than any other crop, with corn and barley not very distant seconds in the degree of expected damage. Rye is not injured so much as these, neither is oats. Millet is severely attacked, so also is Hungarian grass and sorghum. Timothy meadows which are apparently drying out, making little growth, should be examined for this insect. The short-winged form is often found in timothy. This form is incapable of flight and therefore cannot scatter rapidly. Foxtail, crab grass, bottle grass, broom corn and blue grass are all attacked, but blue grass is not a favorite food and generally escapes disastrous attack. Clover,

alfalfa, soybeans, Canada peas, cowpeas, potatoes, garden vegetables and fruiting plants of all kinds are either wholly immune, or so nearly so that the injury is negligible.

RELATION OF WEATHER TO THEIR DEVELOPMENT

A succession of dry summers, especially dry Mays and Augusts, over-lapping into June and September respectively, thus covering the two hatching periods of the insect, is very likely to induce an outbreak in a country that is subject to infestation. Yet outbreaks do not always come with such a succession of dry summers, and a single wet season may not be sufficient to overcome a bad attack; however, the worst part of an outbreak is practically certain to subside after two or more fairly wet years. The rains carry many of the young to the ground and bury them in the mud, float others away, and compact the soil about those just beneath the surface, permanently entombing them. Wet weather also encourages the development of contagious diseases among them. They can stand almost any degree of cold, if steady, and are not necessarily killed by being frozen in the interior of ice. Alternate freezing and thawing may injure them more, but specific data regarding this question are wanting.

REMEDIES

Harvest Measures—When the insects are migrating from wheat to corn, just after the wheat harvest, resort to the following measures, so far as practicable: Have the furrows all made before the wheat is cut and a supply of road oil or tar on hand, so that nothing will need to be done when the insects commence to move, except to string the oil or tar.

With a single shovel plow make a deep V-shaped furrow around the corn field. Make the sides of furrow loose and dusty so that the bugs will fall back when trying to climb out. Make holes every 12 to 15 feet in bottom of furrow to catch the bugs as they crawl along the bottom. When massed in these holes pour kerosene on them or smash them with a wooden pestle. Along the inside of the furrow next to the corn, smooth and firm the bank with a hoe or roller so it will not be dusty, and with a water pot having a tubular spout, pour a slender line of road oil or fluxing oil along the hardened bank. As soon as the first line has soaked into the ground go over the line again and distribute more of the oil. The road-binding oil can generally be obtained from any representative of the Standard Oil Company. The line should be renewed every two or three days, or whenever it becomes so dried out that the bugs are able to cross

over it. Coal tar may be used instead of fluxing oil, but according to Dr. Forbes of the Illinois Station, tar is much inferior, sinking into the ground too rapidly and drying out too soon in the sun and wind. The tar barrier must be renewed about twice per day during the migrating period of the insects. A man or boy giving all his time to guarding such a barrier and keeping it in condition can care for a line 80 to 150 rods long. The tar will cost about 25 cents per day for a line 100 rods in length. The road-binding oil, according to Dr. Forbes' experiments, lasts from five to nine times as long as the tar without renewing and does not cost more than twice as much. The furrow is not very necessary, and the oil line can, in case of emergency, be poured along a level cleared space of firm ground and the post holes can be dug beside the tar line; then the bugs will be trapped almost as readily as if the holes were in the bottom of a furrow. The tar line should be on the side of the holes farthest from the approaching insects, and should barely touch the circumference of each hole, thus encouraging the bugs to move into the angle between the tar line and the circumference of the hole; they will thus prevent any retreat of the leaders and will constantly push them over the edge of the pit. The cleared strip should be about two feet wide or more and after being cleared of weeds may be made smooth and firm by dragging over it a broad, heavily-weighted plank, covered on the under surface with zinc or other smooth metal. A heavy, smooth iron roller, if not too wide, may be used instead of plank. Instead of the level strip, a back furrow may be thrown up and made firm and smooth by dragging over it an inverted, convex-bottomed trough. The tar or oil line is placed on top of the ridge thus made, and post holes are located as previously suggested. Almost any of the coal tar sheep dips may be substituted for coal tar or oil for use on a small scale, but are too expensive for use on a large scale.

If the bugs are already distributed over part of a field of corn, oats or other crop, make the barrier between the clean portion of the field and the part infested. Then spray the infested plants with kerosene emulsion diluted with 8 to 10 parts of water. The stock solution of kerosene emulsion is made as follows:

Laundry soap (chipped), $\frac{1}{2}$ pound.

Kerosene (coal oil), 2 gallons.

Water (preferably soft and free from dirt particles), 1 gallon.

Dissolve the soap in the full amount of water and when this solution is boiling hot, remove from the fire and add the kerosene. Stir the mixture violently by driving it through a force pump back

into the vessel until it becomes a creamy mass that will not separate. This requires from five to ten minutes. The stock emulsion will keep good for months if kept in air-tight vessels.

Kerosene emulsion kills by *contact*, and therefore, the application should be very thorough. The quantity of materials given in the formula will make up 30 gallons of spray for use. The cost per acre for spraying will not be over \$1 for the ingredients. Apply with a spray pump or in case of emergency shake over the infested plants with brooms.

Kerosene emulsion, at the dilution recommended, may not kill all of the bugs which have acquired wings, but is effective against the larvae and nymphs. Sometimes the farmer supposes, from the fact that the insects are plentiful on corn that was sprayed a day or two earlier, that no good has been accomplished, whereas most of the insects hit with the spray were killed, and new migrants afterwards took their places on the corn. Repeated sprayings may be necessary to save the outer rows of a field unless a barrier is interposed between it and the oncoming bugs.

There should be an oil or tar barrier to prevent further migration into the field as well as to protect the clean part of the field. If two or three applications of spray, a day or so apart, have eradicated the bugs from the infested part of the field, the mid-field barrier can be discontinued and attention concentrated on the outside one.

All stages of the insects are killed by pure kerosene and some farmers prefer using this drastic remedy, though it entails the sacrifice of the outer rows of corn. Again, straw is sometimes scattered at the bases of the infested rows and set on fire, burning both corn and bugs. Another method of burning them is to use a plumber's blast lamp, which, if moved rapidly up and down the stalks, will consume the bugs without necessarily doing much injury to the corn. These last mentioned measures, reduced to practice, have not been as satisfactory as the barriers of tar, oil and dust, when supplemented by spraying with kerosene emulsion.

A serviceable barrier between a migrating body of bugs and a cornfield is a strip of millet a rod or two in width. The insects will collect in this, stopping to feed as long as it survives, and when all are collected in it, plow it under to a depth of 8 or 10 inches, working from the outer borders of the strip inward, and immediately harrow and follow with a heavy roller so as to effectually bury all the insects and thus prevent their scattering over the cornfields to breed as soon as provided with wings.

Where for any reason the oil, tar or millet barriers cannot be provided, proceed as follows:

Plow up a strip of ground about ten feet wide around the infested fields, then disk and drag with brush bundles until the soil is pulverized into a fine dust. Now with a short log, from eight inches to one foot in diameter, or with a triangular trough made by nailing two boards together and then weighting with stone, make a furrow by dragging back and forth in the same track until a good ditch has been made across the line of chinch bug march. Where necessary, dress the sides of the furrow with a hoe, making sure that all slopes are even and dusty, so that the bugs will be certain to slip back to the bottom of the furrow when they attempt to ascend. With a post-hole digger make holes every 12 to 15 feet in the bottom of the ditch to catch the bugs as they crawl along the bottom. Kill bugs in the holes as previously directed. This will be a more effective dust furrow than the emergency one made with a shovel plow, previously described. If necessary, use the post-hole digger to clean out the dead bugs and keep the holes in order. Owing to rains and use, the dusty sides of the furrow may become passable to the bugs, in which case it may be renewed by dragging the brush bundle through it again, or it may be better to make a new ditch parallel with the old. In case the new ditch is made, the old may be used for a coal tar barrier if tar or oil is obtainable. The sides of the old furrow should be firmed with a hoe so dust particles will not rattle down on the tar. A slender line of tar should then be strung along the bottom of the furrow, or it may be poured along a line of hardened soil just outside the dust furrow. Remember that the tar line will always be most effective when touching the rims of the holes, and if the holes are made in the bottom of a furrow, the bugs will collect into them faster if the bottom of the furrow is kept compacted and smooth so they can the more readily travel in it. If the temperature is high in the bottom of the dust furrow, from 110° to 120° Fahrenheit, young bugs falling therein will be killed.

Fall, Winter and Spring Measures—From the paragraph on Habits, (p. 4) the reader will be able to draw the inference that either the cleanest kind of culture should prevail over the farm in late summer, all grassy and weedy borders around fields and along fence rows being kept closely mowed to prevent the development of suitable hibernation quarters, or else these should be allowed to grow vigorously so as to entice, in late fall, as many of the insects beneath the shelter as possible. In early winter, after the insects are nicely settled or else in early spring, before they have wakened into activity, burn over all such retreats. If it is impossible or undesirable to burn over woodland retreats, the leaves and trash on the ground may be collected and burned if the prospective damage by

the insects exceeds the value of the humus that would be destroyed by burning. If a bushel or so of leaves are collected and carried into a warm room, keeping them covered with cheesecloth, a day or two will determine if many chinch bugs are hidden among them, since the insects will crawl out and show themselves as soon as the chill has passed from them. The wheat stubble in young clover fields can be burned when the ground is frozen hard, without injury to the clover, but probably insufficient heat would be developed to kill the over-wintering bugs. However, with their shelter removed, it seems probable that alternate freezing and thawing might destroy many of them. Shocks of corn fodder should not be left standing in the field over winter as the bugs sometimes congregate by millions in the butts of these. If the insects are noticed under the shocks when hauling to the barn it will be well to take a spray pump and pure kerosene, or else kerosene emulsion diluted with 2 to 4 parts of water, to the field in another wagon, and spray the bugs on the ground as fast as the corn is removed. Care should be taken to dislodge all bugs from the butts of the fodder by jarring or brushing while loading. The general utilization of corn fodder shocks as traps would do much to ameliorate damage throughout a neighborhood the following season. Do not scatter manure in the fall, when chinch bugs are abundant, unless the manured field can certainly be plowed under deeply in very early spring before the insects have crawled from beneath the shelter and dispersed. After plowing, harrow at once and roll firmly to prevent any of the bugs from escaping. Do not spread barnyard manure on wheat in fall, during chinch bug invasions, for this invites almost certain destruction of the grain the following spring.

The wintered-over adults are very partial to young millet, Hungarian grass and spring wheat, and if borders of these are sown in very early spring around wheat fields, they may prove useful in intercepting many of the insects from entering the wheat and will certainly be useful in stopping the migration of the bugs to nearby cornfields after harvest. As soon as the bugs are about all collected in the grassy border, which will be in two or three weeks after harvest, plow under 8 to 10 inches deep, harrow well to cover all the bugs, and follow with a heavy roller.

If a strip of millet from 10 feet to a rod wide be sown around the borders of cornfields, about 5 to 8 weeks before wheat harvest, it will stop the bugs where they may be dealt with as already advised. Have all furrows made and holes dug and a supply of tar or oil on hand, prior to the harvest, so that nothing will be left to be done after the wheat is cut, except to string the tar.

SUBSTITUTE CROPS FOR WHEAT

If a field of wheat is so badly infested in spring that the crop is to be an evident failure, plow under deeply, harrow and roll, then plant to potatoes, Canada peas, soybeans, alfalfa or garden truck. If there is time to allow it to lie fallow for three or four weeks, after plowing, there will then be a good chance to get a silage crop of corn on it. Wheat is raised by the Ohio farmer because it is a good nurse crop for clover, furnishes straw for manure making, and ripens at a time when it can be readily cared for. After wheat, rye probably comes nearer to meeting these requirements than any other grain. It is a good nurse crop for clover, nearly equal to wheat, and fortunately, is less subject to chinch bug damage than wheat. It is a mistake to suppose that these insects are not able to ruin it, but on the average, the Ohio farmer can reasonably expect at least a fair crop of rye, even when the bugs are quite bad in neighboring wheat fields. Oats also is not greatly injured, and may be used to grow with clover. This crop is not nearly so good a clover nurse as either wheat or rye. Barley is injured less by the bugs than wheat, but ranks among the crops most likely to be damaged, and but little could be gained by substituting it for wheat. Soybeans, Canada peas, cowpeas and alfalfa are nitrogen gathering legumes, which can take the place of clover as soil builders, and they are undisturbed by chinch bugs. If it is desired to get a cover crop on oat stubble during the fall, rye may be used for this purpose, and if it is not desired as a cereal crop with clover the following year, it can be plowed under in the spring as a green manuring crop and the field planted to potatoes, oats or corn, unless full of bugs, in which case the cereal crops might be damaged unless the precautions previously suggested were carefully observed. In a bad chinch bug year, the farmer would probably do better to follow oats with oats or corn with corn than attempt to produce wheat, but some of the immune crops just suggested are much to be preferred.

THE OUTLOOK

If Ohio experiences a dry summer, and rains are light up to seeding time in late September, the odds are rather heavy against the wheat grower in chinch bug districts, especially so since the Hessian Fly is also rather numerously distributed over large areas. A wet spring, next year, might reverse the expectation and save the day, but many farmers, under such circumstances, will prefer to take smaller chances and, therefore, will not sow wheat. If, on the other hand, rains are frequent and general until seeding time in the fall, there is a fair chance to get a crop of wheat next summer. Much will depend on the rainfall next spring, during the breeding season in May and June.

NATURAL ENEMIES AND FUNGUS DISEASES

The chinch bug has but few insect enemies, and none of these make an appreciable reduction in its numbers. Among bird feeders upon the insect, the quail or bobwhite is easily the most important. This bird deserves the full protection of the law, every day in the year for a considerable period of years, because of its important services as an insect destroyer and weed-seed eater. Other Ohio species of birds on record as devourers of the chinch bug are the meadow-lark, redwinged blackbird, brown thrush, catbird, house wren, horned lark and tree swallow, but the combined work of all these makes but little impression on an average outbreak. Entomogenous diseases are more important. For several seasons, we sent cultures of the disease commonly alluded to as "the chinch bug fungus" (*Sporotrichum globuliferum*) to all who applied for it. Last year our cultures seemed to possess little or no virility and would kill very few bugs in our laboratory, even when all conditions were made as favorable as possible. Owing to the prevailing drouth over nearly all the state, it seemed impossible that any good could result from sending out the disease, and since many farmers were inclined to to pin their faith entirely to it without resorting to other and more direct measures, it seemed wisest to discontinue its distribution until weather conditions indicated a possibility that it might again prove useful. This fungus is found naturally in all parts of the State, probably upon every farm, and some investigators believe that, if weather conditions are favorable, it will start up of itself about as quickly as if artificially introduced. However this may be, we are satisfied that it is a mistake to send it out during such seasons as the past six or seven summers have been. The requisite conditions for the rapid and effective development of the contagion are an abundance of moisture and an excess of bugs. Temperatures of 65 to 75 degrees Fahrenheit are very satisfactory, and growth will probably proceed without interference at all temperatures ranging between 50 degrees or lower and 95 degrees or higher. A rather subdued light is congenial, but development doubtless goes forward under all normal illuminations, except in bright sunlight, which would quite certainly be detrimental. The needful shadow for its development is furnished by the growing herbage and the decaying vegetation and litter which covers the soil. Old chinch bugs are scarcely attacked by the fungus, but the young larvae and nymphs are often swept off by millions. Bugs which have died from the disease appear as if dusted over with a fine white or greyish powder. If masses of dead bugs are found close together and powdered over in this manner, it indicates that in great likelihood they died from this disease. Some investigators who have had

wide experience with the disease are confident that artificial dissemination works more rapidly than natural, and advise collecting these diseased bugs and scattering them over fields where the bugs are apparently healthy. To get a good start from a small lot of material, collect a number of bugs, seeking out the larvae and nymphs, and put them with the diseased bugs in a tight wooden box containing a thin layer of earth in the bottom. Supply the imprisoned bugs with fresh corn stalks as often as necessary, and keep the contents of the box moist by sprinkling water over them. As fast as the bugs show evidence of disease, distribute a part of them over the fields and supply their places with fresh bugs. Keep up this operation till a goodly number of fungus-covered bugs are distributed in the worst infested areas. If by chance the boxes become foul, they should be carefully cleaned and thoroughly aired. Should we reach the conclusion that there is a probability of lending practical assistance to the farmers in hastening the work of the fungus, we will resume the distribution of the meal and beef-broth cultures. Parties having what they suppose to be the disease upon their premises can have specimens identified by sending the same to the Experiment Station.

ACKNOWLEDGEMENTS

In preparing this treatise, I have freely referred to the writings of Prof. F. M. Webster and Dr. S. A. Forbes, the two Entomologists who have given closest study to the species, but have also consulted other authorities, and practically all of the observations herein recorded and remedies here recommended have at one time or other been confirmed or tested by some of the members of our Entomological staff. Plate I is photographed from a lithographic plate by Dr. Forbes.* The other illustrations are from negatives made by Mr. Goodwin.

*Twenty-third Report State Entomologist of Illinois, Plate I.

JUN 21 1915

Ohio Agricultural Experiment Station

CIRCULAR No. 116.

WOOSTER, OHIO, SEPTEMBER 1, 1911

THE RURAL POPULATION OF OHIO WHERE IS IT INCREASING AND DECREASING? WHY?

By L. H. GODDARD

A study of the changes in the rural population of Ohio and of the causes that have operated to bring them about is considered an essential feature of an Agricultural Survey of the State such as is now being conducted by the Ohio Experiment Station. A State may have specially valuable agricultural resources and yet be of little agricultural value to the nation at large unless it possesses an abundant and stable rural citizenship.

In connection with this Circular we reproduce four of the maps which are being used in such a study and to which the attention of those who are interested in such problems is invited. The map given in Figure 1 shows the decreases, if any, in rural population in each rural township of the State between the years 1900 and 1910 as determined and reported by the U. S. Census Bureau.* Each dot on this map represents a decrease within this 10-year period of one percent in the rural population of the township on the map of which it is placed. Five dots show that there was a decrease of five percent, ten dots a decrease of ten percent, and so on. The

*The statistics, which were sent to the press by the Census Bureau in March, 1911, are subject to correction in the later and final publication. The corrections, if any, however, will doubtless be insignificant, and owing to the nature of this study need not be considered in connection with it.

absence of dots indicates that there probably was a gain, or at least no decrease. Whether or not there was a gain may be determined from the map in Figure 2. It will thus be seen that in Figure 1 the greater the number of dots, or roughly speaking, the more dense the map is made with dots in any township or section, the greater has been the decrease of the rural population in that township or section in the period named. A single exception to this rule will be noted in the case of townships in which are shown a small cross. The presence of such a cross on the map of a township indicates that for some reason it was necessary to reject the figures for that township. The Station will be pleased, however, to supply, upon request, all the information available regarding any of the townships so marked.

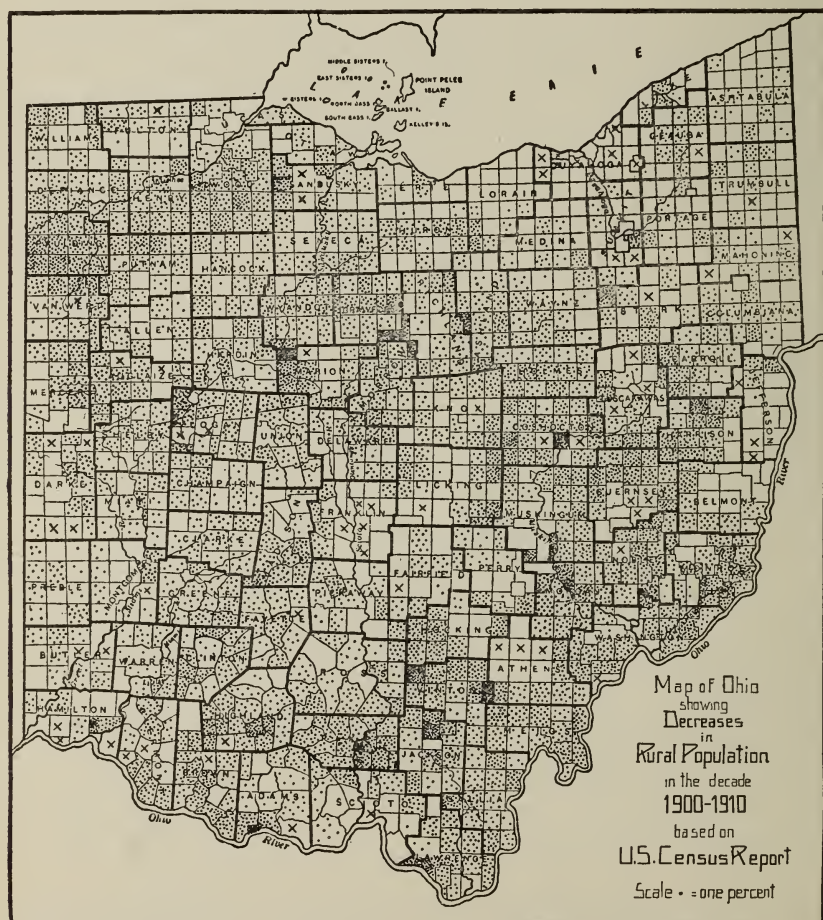


FIG. 1

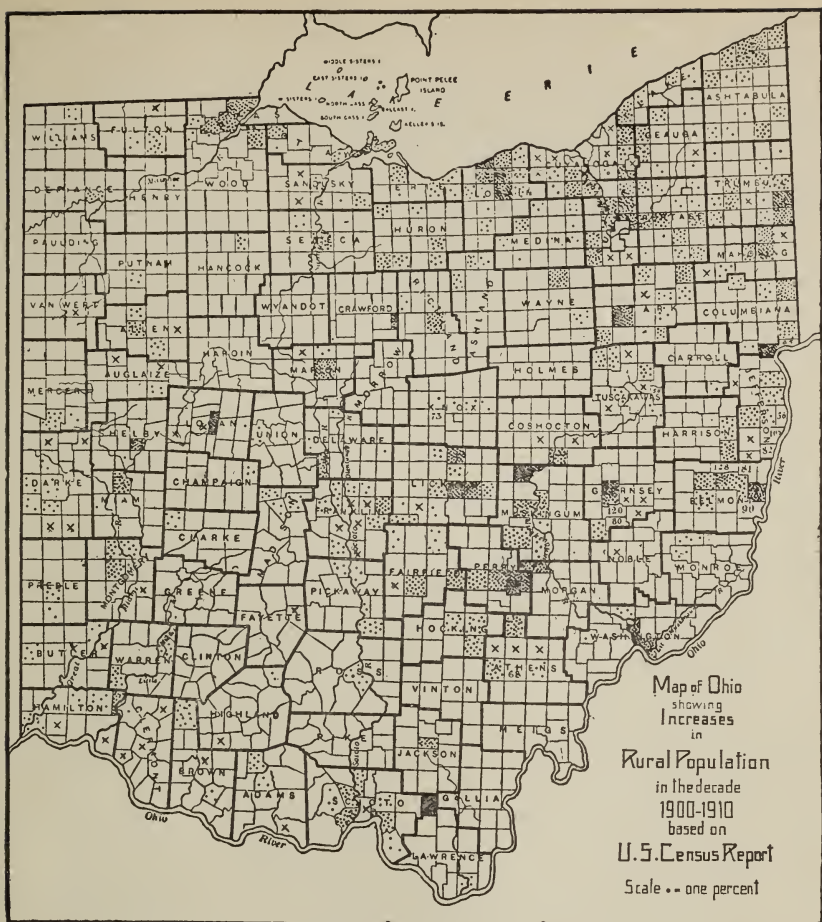


FIG. 2

The map in Figure 2 shows in a similar manner the increases instead of decreases in the rural population between 1900 and 1910. In this case the dots each represent one percent of increase instead of one percent of decrease. Accordingly, the greater the number of dots or the blacker the map of any township, the greater has been the increase in that township. On this map will be noted another exception to the dotting system. In some townships the gain was so great that it was impossible to plot on their maps the number of dots corresponding to the percentage of gain. Accordingly, the figures of percentage have been used instead. For instance, the number 80 within a township would indicate that the rural population of that township had gained 80 percent within the ten-year

period. The maps given in Figures 3 and 4 represent respectively in a similar manner the decreases and increases in rural population between the years 1890 and 1900.

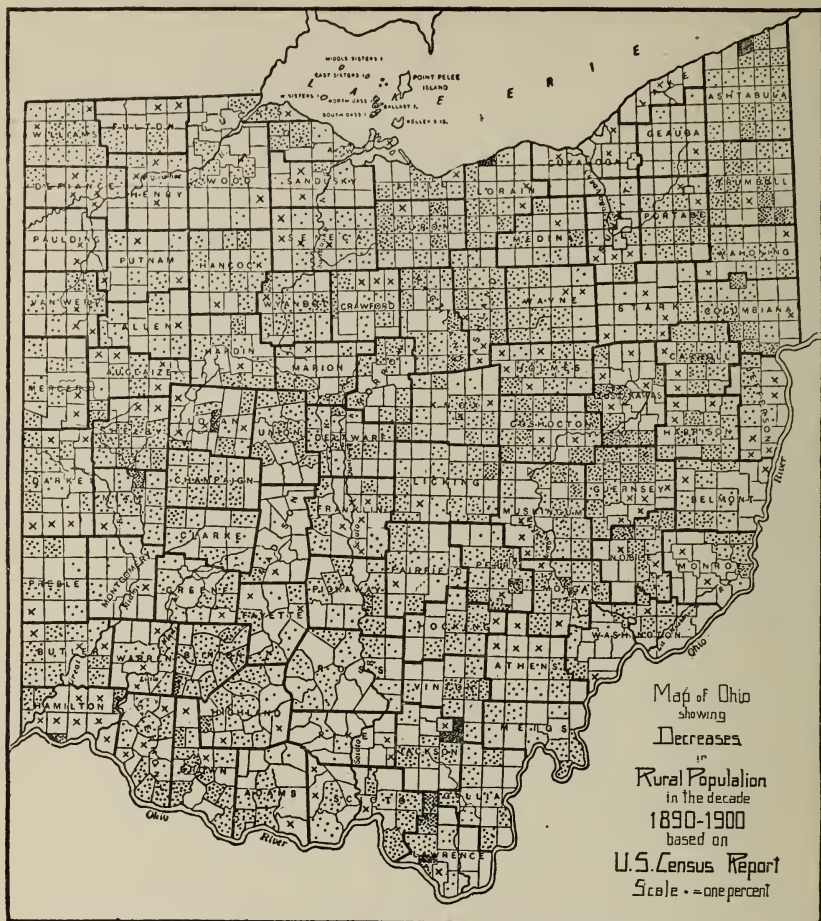


FIG. 3

In its studies of urban and rural population the U. S. Census Bureau defines rural population as that which does not reside in cities or other incorporated places of 2500 or more inhabitants. In a study such as is being made by the Ohio Station in which conditions are being analyzed township by township, it was deemed necessary to go more into detail. Accordingly, it was decided to define rural population in this study as that which does not reside in cities or villages which are incorporated. By using this classification instead of the one used by the Census Bureau, the population

of some 644 towns, totaling in 1910, 453,289, almost ten percent of the population of the State, was transferred from the rural to the urban class; but the population of many other unincorporated towns, some much larger than those which are incorporated, was classed as rural. While there are doubtless many persons residing in these small incorporated towns whose interests and inclinations are even more rural than are those of many who live in the open country, and therefore should be classed as rural, it is, on the other hand, probable that for every such a one there is at least one in the unincorporated towns which are classed as rural, whose interest is entirely urban.

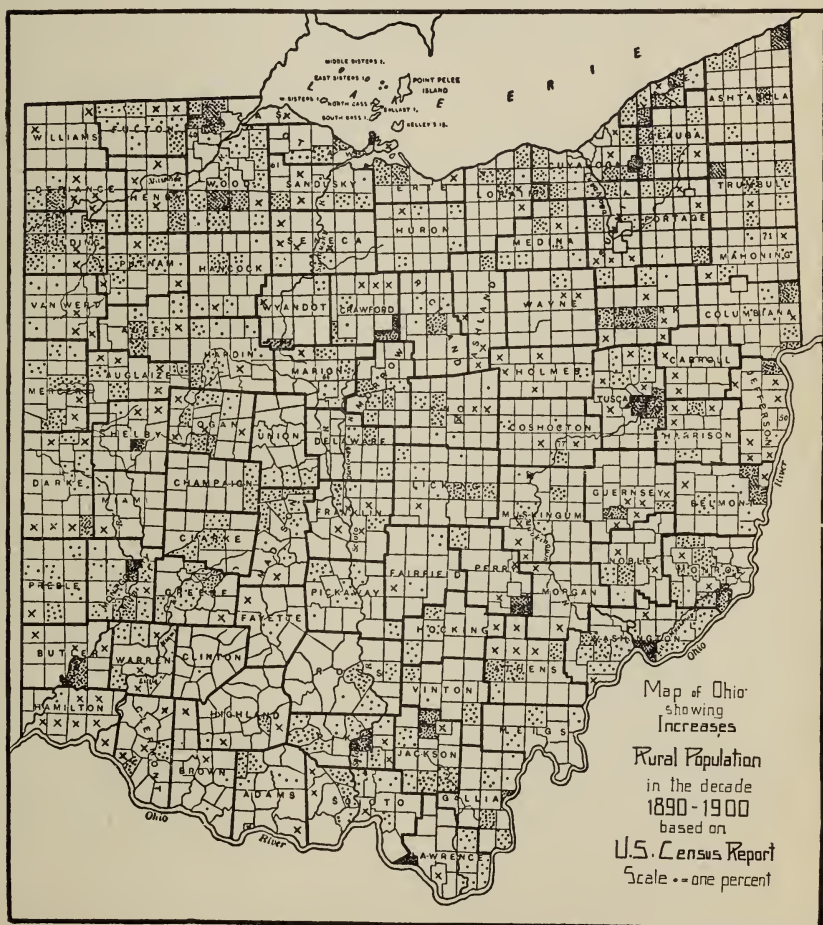


FIG. 4

With this classification in mind it may be well to turn again to the maps. An examination of the map in Figure 1 for the decade 1900 to 1910, will reveal the fact that there was not a county in the State which did not lose in agricultural population in at least four townships. Eleven counties show a loss in all townships. Ten more have lost in all but one township and thirteen others have lost in all but two townships. In this list of thirty-four will be found many of the best agricultural counties of the State. Indeed, one of the most productive counties in the State shows perhaps the heaviest and most uniform losses in population. Taking the State as a whole, out of a total of 1,352 rural townships, 947 or 70 percent showed a loss in population in this period. Probably 70 percent of the 60 which have been "crossed out," as previously mentioned, would also have shown a similar loss had it been possible to make the comparison.

POPULATION OF OHIO

(FIGURES FROM U. S. CENSUS BUREAU)

	1890	1900	Increase Percent	1910	Increase Percent
Total for State.....	3,672,316	4,157,545	13.2	4,767,121	14.7
Urban.....	1,829,862	2,394,001	30.9	3,116,837	30.2
Rural.....	1,842,454	1,763,544	-4.3	1,650,284	-6.4
Percent Rural.....	50.2	42.4	-15.5	34.6	-18.4
Loss in rural population in preceding decade.....	....	78,910	....	112,707	....
Average loss per township (1352).....	....	58.4	....	83.4	....

In 1890 the rural population of Ohio, according to the foregoing table and classification, amounted to 50 percent of the total for the entire State. In 1900 this percentage had decreased to 42 and in 1910 to a little less than 35. It will be noted also that whereas the State population increased fairly uniformly, a little less than 15 percent each decade, and the urban population increased in a similarly uniform manner at about 30 percent for each period, the rural population, on the other hand, actually decreased 4.3 percent the first decade and 6.4 percent the second. The average decrease per township in the first decade for the entire number of rural townships (1352) was 58 persons and in the second decade 83 persons. Since many of the townships which made gains made very pronounced ones (see Figure 2) it is probable that the average actual loss in the 947 townships which did lose in population in the second decade, was not less than double the average for the entire 1352, or from 150 to 175 per township.

From the foregoing it will be evident that the rural population of Ohio is not only not keeping up with the urban population but also that it is actually decreasing at an appreciable rate which is growing larger as the decades go by. The question then arises, how long can these townships continue to lose from 10 to 15 or more people per year as have 70 percent of the townships of Ohio, many of which are in the most productive areas of the State, and not have some very definite effect on the State at large, at least on its agricultural production. The decrease for the past ten years was 40 percent greater than between the years 1890-1900. Will it be greater or less in the succeeding ten years? What are the causes that are bringing this about? Are these changes normal, and if they are not normal, what can be done to remedy the condition?

Again the Experiment Station invites every person who is interested in this problem to study these maps and to favor it with their suggestions and ideas regarding this problem. It desires especially to hear from those who have made accurate observations themselves of the conditions in any rural township in Ohio throughout the past ten, fifteen or twenty years. An examination of the maps as a whole, and especially those shown in Figures 1 and 3, may be of assistance in determining these suggestions. In the map of the last decade (Figure 1) note that the largest light area is in the north-eastern part of the State. Try to explain that and the small, light areas such as that in the south-western part or the light streak across Lucas, Fulton, and Williams counties. By studying the maps in this way many ideas may develop. The "Why" in connection with this decrease in rural population needs to be answered if possible and it is hoped the thinking people of the State will assist in answering it. A member of the Station staff will begin, this year, as a part of the Agricultural Survey, a field study of the history of the agriculture and the people of the State. It will be manifest, therefore, that any suggestions offered will be put to good use. Persons who desire it will be visited in connection with this field study.

The computations and plotting in connection with the maps in this Circular were conducted by Miss Marion Carrington assisted by Mr. Hubert Shellenberger, both of the Department of Cooperation.

Approved:

CHAS. E. THORNE, *Director.*

Saf

Ohio Agricultural Experiment Station

CIRCULAR No. 117.

WOOSTER, OHIO, OCTOBER 1, 1911

VARIETIES OF CORN IN OHIO

BY GAIL T. ABBOTT



A Field of Woodburn's White Corn

CHAS. E. THORNE, *Director, Ohio Agricultural Experiment Station:*

SIR:—I have the honor to transmit herewith and to recommend for publication as a Circular by the Experiment Station the accompanying manuscript entitled "Varieties of Corn in Ohio."

This paper, which has been prepared by Mr. Gail T. Abbott, formerly of this Department, is based on a field study which reached into all sections of the State. In it twenty-seven of the varieties or strains of corn in use in Ohio are described and a general idea given as to the localities in which each is grown.

This report is offered as a contribution to the Agricultural Survey of the State.

Respectfully submitted,

L. H. GODDARD,

Chief of Department of Cooperation

Approved:

CHAS. E. THORNE,

Director.

VARIETIES OF CORN IN OHIO

BY GAIL T. ABBOTT

INTRODUCTION

During the last half-dozen years much thought has been given to the consideration of the corn crop in Ohio. Corn shows, which were almost unheard of ten years ago, are now too common to excite comment. The comparative merits of the different varieties of corn have been discussed in every section of the state.

However, there is yet much confusion in the minds of many people regarding the characteristics of many of even the more widely known varieties. Of the far larger number of varieties that have been grown locally only, there are few whose characteristics are known outside of the section of the state where they originated.

It is hoped that this circular will not only help to produce in the minds of Ohio farmers a more definite impression of the characteristics of each of the varieties illustrated, but will also preserve for future generations a little of Ohio's local history as we find it written into one of her greatest crops. He who by painstaking care during a period of years originates or develops a strain of corn adapted to local conditions has rendered agriculture a notable service. It is only just that we recognize the service and honor the benefactor.

In order to secure as much information as possible regarding the history of corn varieties and the sections of the state where they are now grown, a circular letter was sent to a list of farmers which represented all parts of Ohio. In the list were included questions regarding the name, origin and early history of the variety grown on the reporter's farm, the length of time it has been known in the locality, the length of season needed and the type of soil on which the corn was grown. Questions were also asked as to the names of the more common varieties grown in the reporter's locality and the proportionate acreage devoted to each. Nearly 500 answers

to these letters were received. The grain dealers of the state also furnished considerable information regarding the varieties in their localities in reply to a similar circular letter. In this investigation, the author of this circular has visited, within the past two years, 168 specially selected and well distributed farms. Other representatives of the Experiment Station, with this corn investigation in mind, have visited many other localities. The entire state may therefore be said to have been fairly well covered in person. The observations noted in this circular are based on information from all of these sources.

On the following pages will be found illustrated descriptions of twenty-seven of the so-called varieties of corn that have been observed in this investigation, together with notes regarding the localities in which they are being grown. It is hoped that persons interested in the subject will advise us regarding anything that may seem to be in error or regarding varieties that may have been omitted. While much care has been taken to make the study as comprehensive and accurate as possible, it will be manifest that in two years' time it has been impossible to make a complete survey of the corn varieties of the entire state. It is only by the assistance of the corn growers themselves that we have accomplished this much and may hope with the funds available to develop anything like a complete survey at a later date.

In this connection thanks are extended to all farmers and grain dealers who replied to the circular letter; to all who sent in samples of corn for examination; to other members of the staff of the Department of Cooperation, and to all who were so kind as to render special assistance as the need developed. The photographs used to illustrate this circular were all made by the Station photographer, Mr. Wm. P. Beeching, Jr.

CORN VARIETIES DESCRIBED

INDENTATION

In describing the indentation of the grain of the different varieties the following terms are used: (1) dimple dent—a smooth round dent such as is found in many grains of Leaming Corn; (2) smooth dent—similar to No. 1 except that the dent is long instead of round; (3) crinkled dent—this is a long dent which is crinkled instead of smooth as in No. 2; (4) pinched dent; the cup is long, crinkled and the edges somewhat pinched toward each other; (5) pinched dent with a beak, which is found in the Hackberry varieties; the cup is crinkled and the edges drawn together as in No. 4, but one edge is much longer than the other and forms a somewhat sharp point.

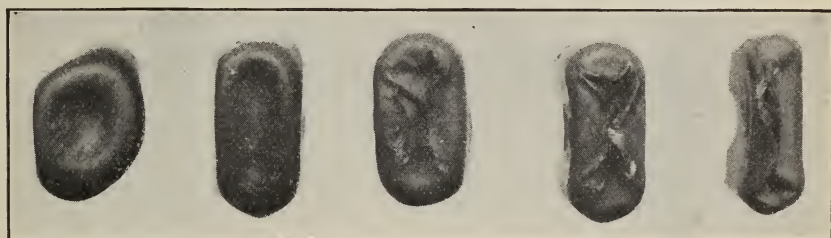


Fig. 1. The five different classes of indentation mentioned in this circular

CLARAGE CORN

This variety, while not as well known or as widely distributed over the state as one or two others, probably has the longest history of any corn that can rightly claim Ohio as its birthplace. The originator, Edmund Clarridge, was born in eastern Maryland, October 2, 1789 and moved with his parents to Ross county when he was twelve years of age. He remained there until he was twenty-four, when he married and moved north-westward to set up his new home near Duffs Forks in the north-east corner of Fayette county. In 1867 he died, but his sons who remained on the farm continued to perpetuate the type of corn which their father had originated.

In about 1855 a son-in-law, A. B. Core, who lived at Sedalia, chose ears which showed an amber color and began to work for a larger, longer ear with a deeper grain. This new strain which he called "Improved Clarage" had a chaffier type of kernel than the old strain fixed by his father-in-law, and was later in maturing.

The ears of Clarage corn are very slowly tapering, from 8 to 9 inches in length, circumference 6 to 7½ inches, with 14 to 18 rows of grain which usually run straight on the cob. The space between

the rows of grain is medium, kernels are 9-16 inch in depth, of deep yellow color, crinkle-dented, with germ medium in size. Butts are rounded and tips usually well filled. Shank is small, cob is red and medium sized. From the first an occasional red ear appeared. These red ears still appear, though more rarely than they did years ago.

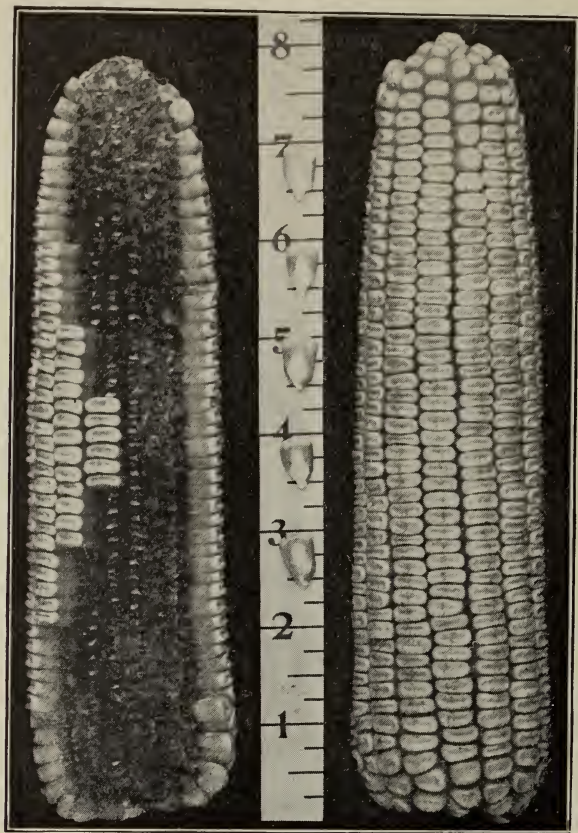


Fig. 2. Clarage corn

The foundation for this corn which came later to bear his name was the native corn which Mr. Clarridge found being grown by his neighbors when he moved to Fayette county. The first characteristic which he had in mind when he chose his seed corn was the early ripening of the ears. In order to get early ears he chose his seed from the stalk, selecting the ears that ripened first. His ideal ear was one that had straight rows which were carried out well over the tip. He wanted the grain to be deep. He was particular also about the color, desiring a deep yellow grain with a honey yellow cap.

Under the bran he wanted a flinty grain, believing that a kernel of this character had more feeding value than a grain of a more starchy nature. With these ideals in mind and always selecting his seed from the stalks, he soon developed a type of corn whose characteristics were well fixed.

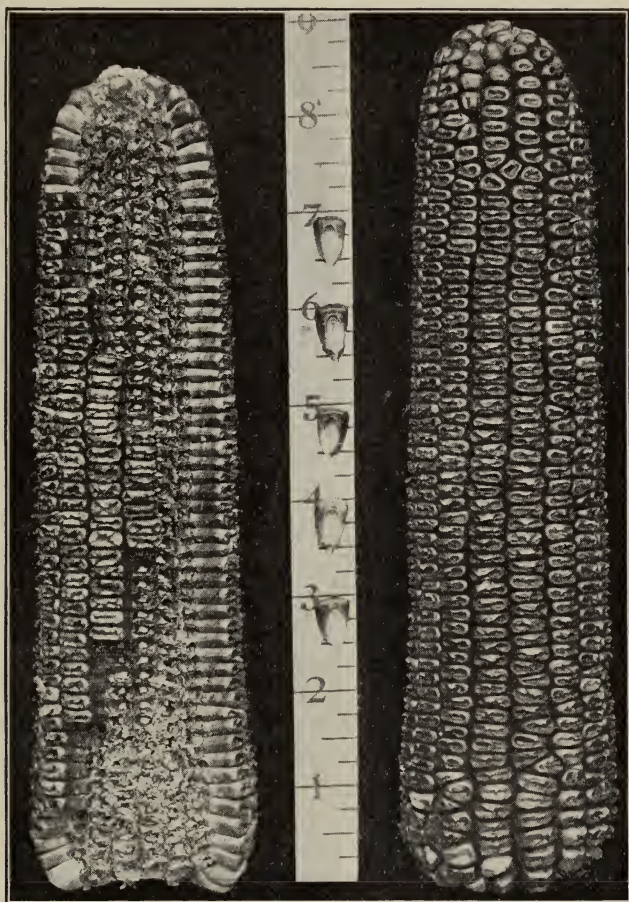


Fig. 3. Rotten Clarage

In those days as at the present time there were occasional years when much of the corn failed to mature properly and good seed was scarce. When such years came Mr. Clarridge's neighbors always knew where to go for good seed. Slowly it was carried into the counties lying adjacent and came to be known as Clarridge corn. Clarage, as the name is spelled today, is a mis-spelling of the old name Clarridge. The seed has been carried to many of the western

corn states. It is grown quite extensively in Fayette, Franklin, Clinton, Greene, Highland and to some extent in the western counties lying further north. It has been the standard variety at the Experiment Station ever since its location at Wooster in 1893. It matures safely there. Mr. Clarridge considered it specially adapted to clay land when well manured, though it does well on other soils. When grown in black land it produces a chaffier type of kernel.

ROTTEN CLARAGE

The origin of the variety called Rotten Clarage is unknown. It is commonly considered a cross between Clarage and a blue corn which came, possibly, from Mexico.

The ears are 8 to 9 inches long; with circumference 6 inches, and cylindrical. They have 14 to 18 straight rows, furrows close, butts rounded, tips regular and well filled, and medium sized cobs of red color. The kernels are 8-16 inch deep, crinkle dented, color yellow intermixed with blue or black.

This variety is found in Highland, Ross, Fayette, Madison and the adjacent counties to a limited extent. It is held in high esteem by feeders but is usually discriminated against by elevator men, although this is not the case in some localities where large quantities are grown.

LEAMING*

Leaming corn was originated in 1856 by J. S. Leaming in Clinton county, Ohio. The original seed he purchased in Hamilton county, Ohio, the year previous, while on a trip across the country. By continuous selection he fixed the type which we find today grown by his sons, P. D. Leaming at Wilmington, where the father developed the variety, and J. S. Leaming at Waynesville.

As in the case of Clarage corn, during the time of its development, as well as since, the seed was selected from the stalks, because Mr. Leaming preferred a certain type of stalk. His ideal stalk was of medium height and had a large number of broad leaves. It was thick at the base and tapered rapidly to the tip which bore a large, spreading tassel.

This ideal stalk bore the ear not too high from the ground. It hung at the end of a rather long, thick shank and when the ear ripened it hung downward beside the stalk. Mr. Leaming was much pleased if he could select all his seed ears from stalks which bore two ears, for he believed that this indicated the ability to succeed under adverse conditions.

*For a more complete history of this variety of corn see paper by W. A. Lloyd of the Ohio Station in the 3rd Annual Report of the Ohio Corn Improvement Association, page 87. Copies of this paper may be secured by addressing the Ohio Experiment Station.

The distinguishing characteristics of this variety are its very tapering ear with somewhat irregular rows of grain of a deep yellow color. The length of ears is $8\frac{1}{2}$ to 10 inches, circumference 7 to $7\frac{1}{2}$ inches, with 16 to 22 rows and medium space between the rows. The butts are large with large shank, making it somewhat hard to break the ear off; tips are irregular, pointed and well covered with thick grains. Cobs are large, tapering and red in color; grain is deep yellow color, 8-16 inch deep, dimple dented. Mr. Leaming chose tapering ears because he believed that this indicated early maturity. His aim was to produce a variety of corn that would mature in 100 days.

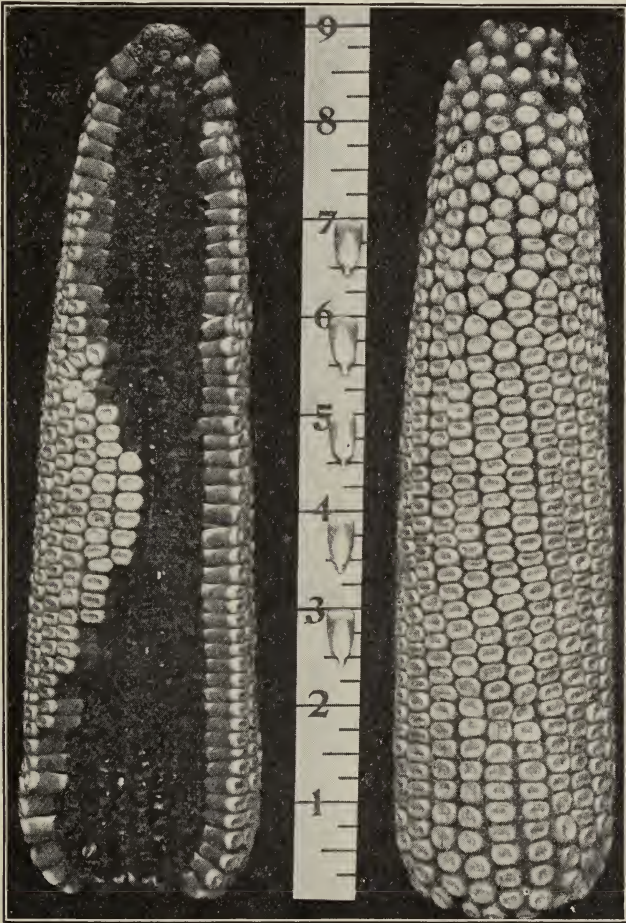
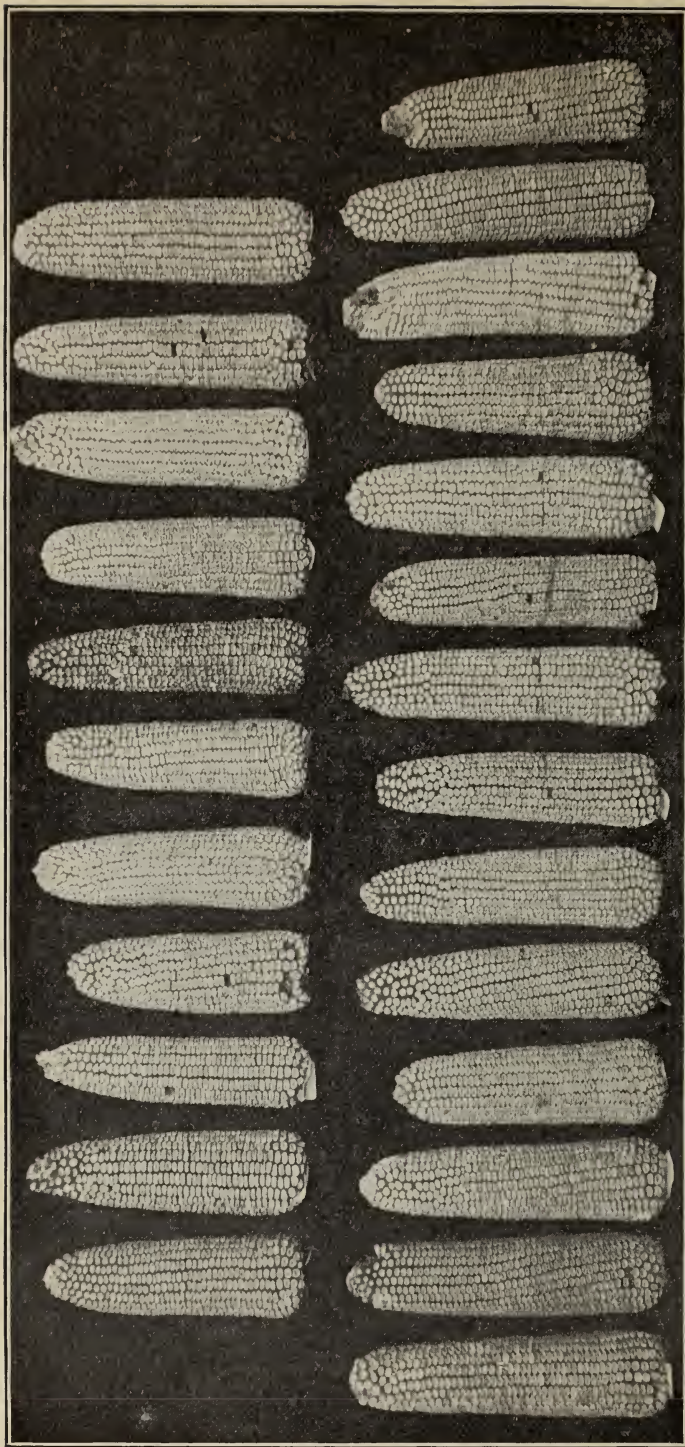


Fig. 4. Leaming ears from the farm of P. D. Leaming, Wilmington, Ohio



1	2	3	4	5	6	7	8	9	10	11	24	25
12	13	14	15	16	17	18	19	20	21	22	23	

Fig. 5. Showing twenty-five ears of Leaming corn, each ear representing the corn grown by a different man,
(See list of names on page 32)



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

Fig. 6. Showing twenty-five ears of Learning corn, each ear representing the corn grown by a different man,
 (See list of names on page 32)

Contrary to the usual custom at that time his corn was planted in drills, one grain in a place about 12 to 14 inches apart. This he thought gave each plant a better opportunity to develop. During cultivation, much of which was done by the family of 7 sons, with hoes, all the weak stalks and those which produced no ears were cut out. Cultivation continued till the silks appeared.

By these methods Mr. Leaming was able to produce over 100 bushels of corn per acre. This was a remarkable yield and it caused his fame to spread. Men came to buy seed of the corn that produced such large yields. While Mr. Leaming believed that he had a superior strain of corn, he gave most of the credit for his large yields to the superior cultivation which he gave the crop.

From this origin, Leaming corn has been distributed from one end of Ohio to the other. Many men grow corn the seed of which they bought under that name. A far larger number grow a nameless variety that bears within itself evidence of a mixture of Leaming at some time in its history. In central Ohio in the latitude of its home it is medium early in maturing, ripening in a shorter season than most of the other varieties found there. In northern Ohio, especially in the western part, much of it is grown, but it requires the full season to mature. Henry county grows many acres each year for a seed company. Only an occasional farmer in north-eastern Ohio grows it, since the season there is a little too short for it to mature safely except on some of the very best land.

Names and addresses of growers of ears of Leaming corn shown in Figures 5 and 6.

No.	Grower	Postoffice	County
1	N. C. Frost	West Mentor	Lake
2	G. H. Holden	Wakeman	Erie
3	G. E. Tillotson	Brunswick	Medira
4	Arthur Moore	Cuyahoga Falls	Summit
5	D. W. Galehouse	Marshallville	Wayne
6	D. J. Weaver	Marshallville	Wayne
7	Hiram Stoll	Marshallville	Wayne
8	Alec Shank	Sugar Creek	Tuscarawas
9	Jas. D. Lyle	St. Clairsville	Belmont
10	J. A. Arnold	Vincent	Washington
11	G. L. Fleming	Amesville	Athens
12	G. W. Stipe	West Unity	Williams
13	J. C. Gusey	Archbold	Fulton
14	Jacob C. Lew	Archbold	Fulton
15	Walter Battershell	Hicksville	Defiance
16	S. B. Walbolt & Son	Waterville	Wood
17	Dan Schleppe	Valley Crossing	Franklin
18	F. C. Murphy	Sunbury	Delaware
19	Clifford Zerbe	Delaware	Delaware
20	Grover Nuding	Mendon	Mercer
21	J. A. Linville	Urbana	Champaign
22	John Saring	Troy	Miami
23	Joseph Allen	West Chester	Butler
24	F. A. Bradley	Oxford	Rutler
25	Chas. Reinbott	Batavia	Clermont

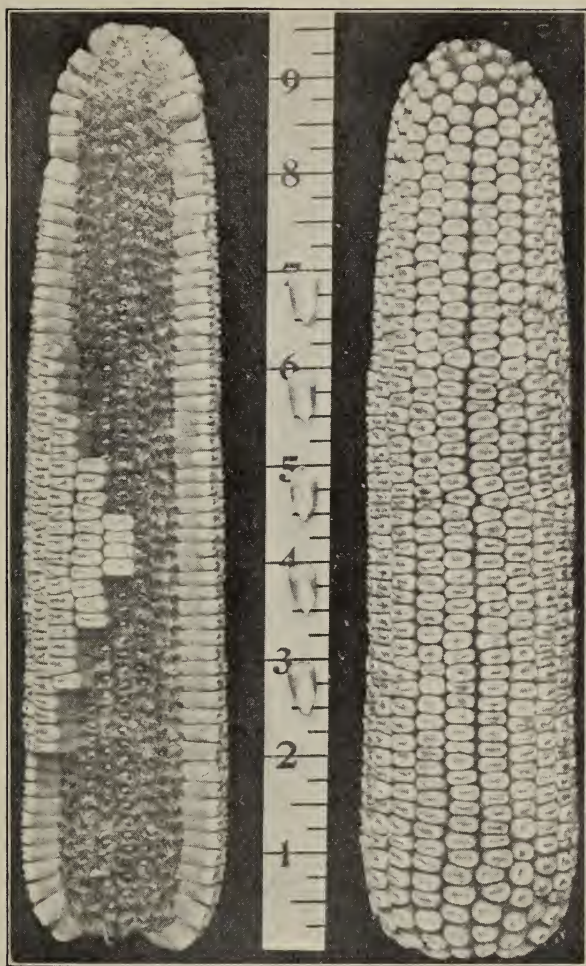
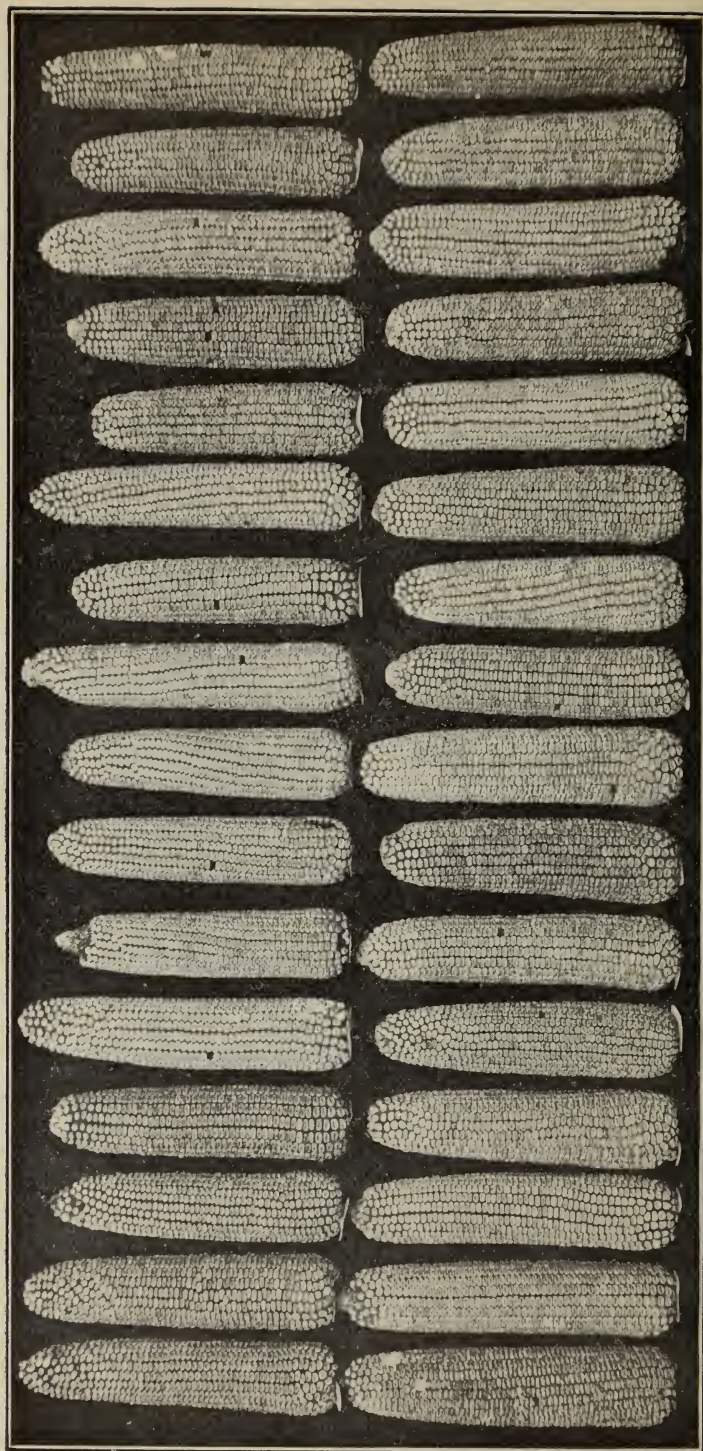


Fig. 7. Ears of Reid's Yellow Dent corn

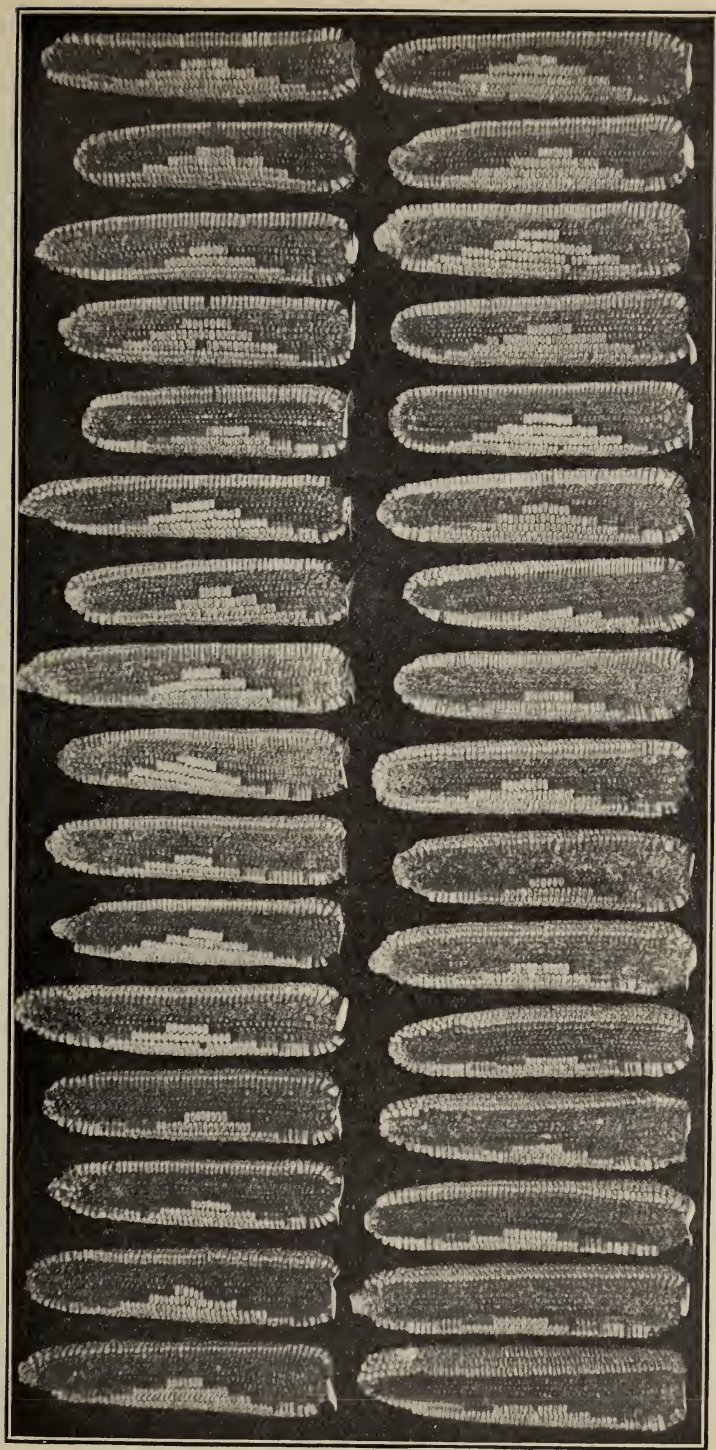
REID'S YELLOW DENT

Reid's Yellow Dent corn was brought into Ohio from Illinois only a few years ago. It is, however, the result of a cross of an Ohio and an Illinois variety, made in 1846 by Robert Reid, who moved to Red Oak, Illinois, from Brown county, Ohio. It has become very popular here in corn shows, winning the best prizes in the majority of cases where shown.



17 2 18 3 19 4 20 5 21 6 22 7 23 8 24 9 25 10 26 11 27 12 28 13 29 14 30 15 31 16 32

Fig. 8. Showing thirty-two ears of Reid's Yellow Dent corn, each ear representing the corn grown on a different farm.
(See list of names of growers on page 36)



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32

Fig. 9. Showing thirty-two ears of Reid's Yellow Dent corn, each ear representing the corn grown on a different farm.

(See list of names of growers on page 36)

Names and addresses of growers of ears of Reid's Yellow Dent corn shown in Figures 8 and 9.

No.	Grower	Postoffice	County
1	D. G. Hoftizer	Olmstead Falls	Cuyahoga
2	C. A. Martin	Wooster	Wayne
3	M. A. Page	Dennison	Tuscarawas
4	E. C. Darling	Nellie	Coshocton
5	F. C. McMunn	Lore City	Guernsey
6	H. W. Hawthorne	Belmont	Belmont
7	C. A. Beacham	New Lexington	Perry
8	J. H. Morrison	Evergreen	Gallia
9	Dale McCormick	McCormick	Gallia
10	Dan Egbert	Tiffin	Seneca
11	Jas. W. Cook	Forest	Hancock
12	E. Steinhilber & Sons	Bucyrus	Crawford
13	F. C. Murphy	Sunbury	Delaware
14	M. S. King	Newark	Licking
15	Eli Gabriel	Milford Center	Union
16	Chas. Enz	Payne	Paulding
17	Chas. Enz	Payne	Paulding
18	E. A. Field	Payne	Paulding
19	R. O. Evans	Venedocia	Van Wert
20	Dan Lininger	Coldwater	Mercer
21	P. O. Stockstill	Sidney	Shelby
22	C. H. Long	London	Madison
23	C. H. McKay	New Burlington	Greene
24	Alexander Gump	Fletcher	Miami
25	Roscoe Straley	Jeffersonville	Fayette
26	Roscoe Straley	Jeffersonville	Fayette
27	G. O. Vanorsdal	Jeffersonville	Fayette
28	Otto J. Augspurger	Middletown	Warren
29	Aaron Sharritt	Germantown	Montgomery
30	O. O. Zehring	Germantown	Montgomery
31	Hershel Climer	Gillespieville	Ross
32	W. F. Bach	Georgetown	Brown

The ears are $9\frac{1}{2}$ to $10\frac{1}{2}$ inches long, with circumference $7\frac{1}{4}$ to $7\frac{1}{2}$ inches. They are cylindrical and slowly tapering at the tip, with straight rows very closely spaced. The butts taper slightly toward the shank, which is very small. This causes the ear to fall easily if cut with the corn harvester. The grains are square-topped, rather narrow, and often open-spaced next the cob. They have small germs, are lemon yellow in color and indentation is dimple or crinkle dented. The cobs are small and red. This variety has given good results on the best land in the west-central part of the state. In the south-eastern section it has done very well on the best river bottom land when planted early. On the thinner soils of this section, as well as of the northwest section, it should be tried only in a small way and then only when the conditions are most favorable. It seems not yet adapted to northeastern Ohio.

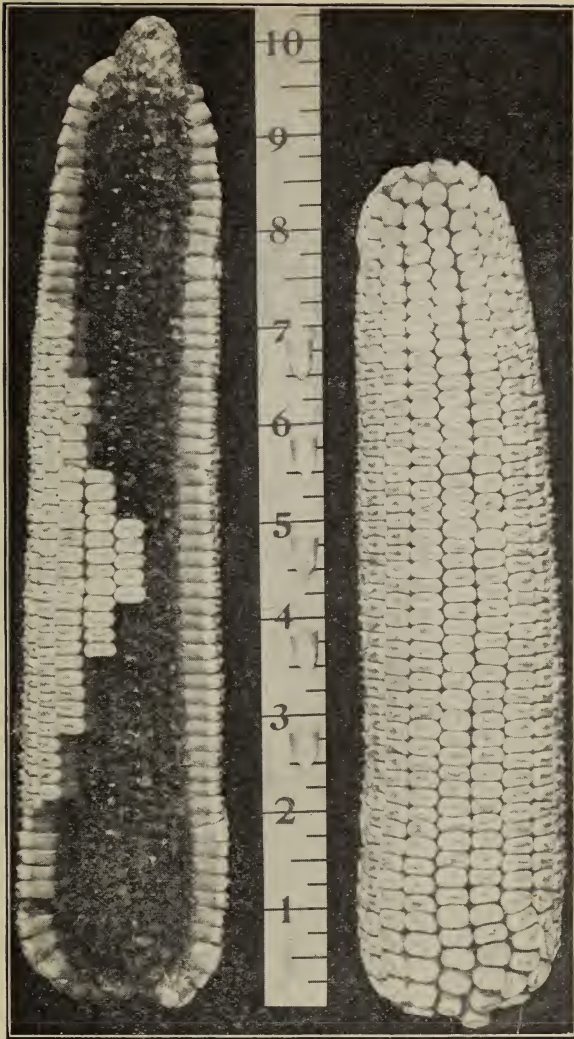


Fig. 10. Ears of Monitor corn

MONITOR CORN

Monitor corn, a variety which has been put out by a New York seed company, is a strain of the Funk's Yellow Dent. It has been tried by only a few farmers in Ohio and should be used at first in a small way only. Probably it is not adapted to northern Ohio, and especially northeastern Ohio.

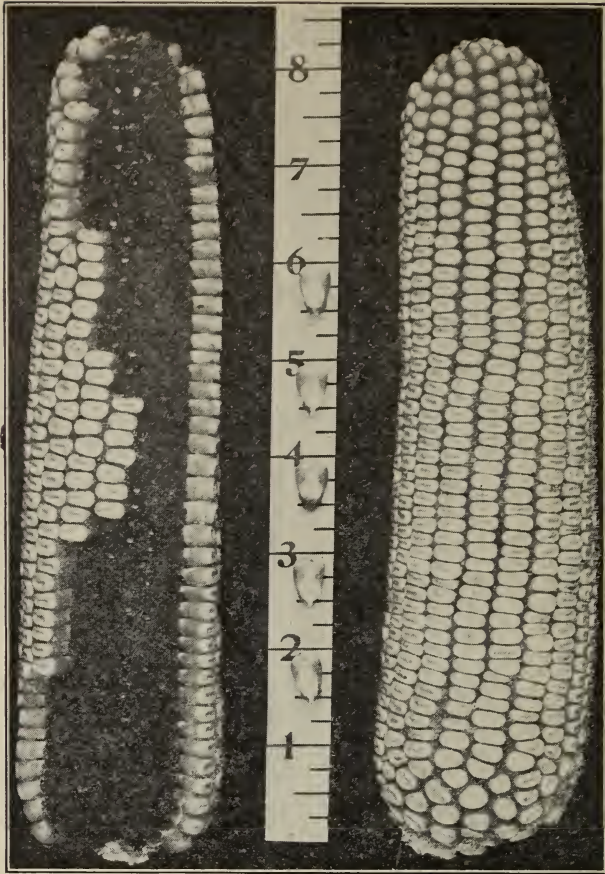


Fig. 11. Ears of Ohio Pedigreed corn

OHIO PEDIGREED No. 75

This variety has been bred by the ear-row method from Reid's Yellow Dent corn by Jas. W. Cook of Forest, Hardin County, Ohio. He began his work about five years ago and in all cases has fulfilled the requirements of the Ohio Plant Breeders' Association. The general characteristics of this variety or strain are much the same as of Reid's Yellow Dent, but the grain is not as deep and the indentation is smoother. It requires nearly as long a season to mature as does Reid's Yellow Dent. It is probably safe to try wherever Reid's Yellow Dent succeeds.

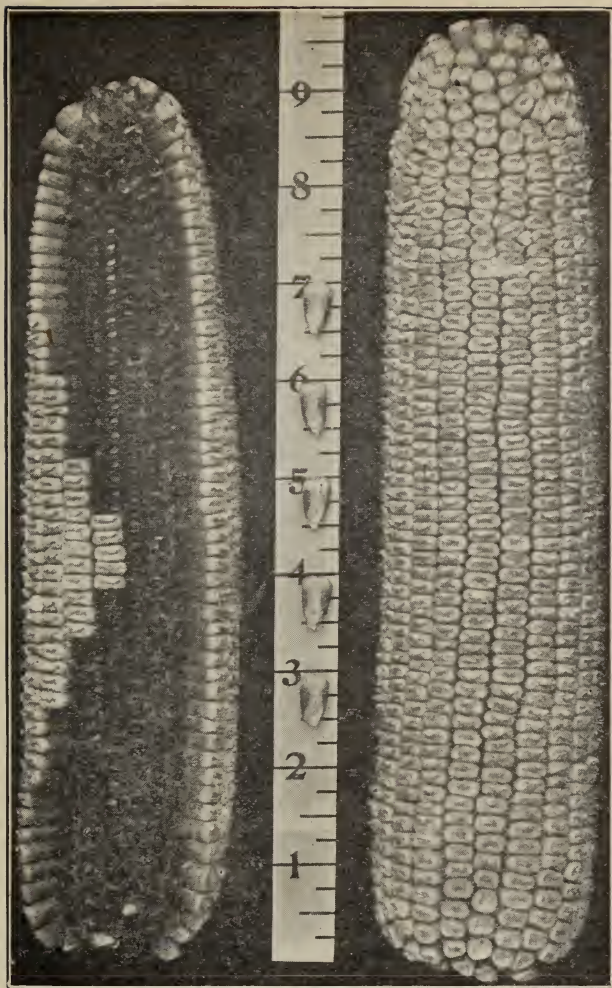


Fig. 12. Ears of Baker's Early

BAKER'S EARLY

Baker's Early has been developed by selection from the Pittsenbarger corn which has been grown by the Baker family on their farm at Greenville, Darke county, for about 60 years. The Pittsenbarger corn was a mixture of a deep-grained red corn and a yellow variety having 14 to 16 rows. About 40 years ago Noah Baker began to select the type now known as Baker's Early. Recently he passed the work on to his son Frank.

The ears of this variety are cylindrical, 8 to 9 1-2 inches long, 7 1-4 inches in circumference, with 18 to 22 straight rows of grain and rows close together. Butts are rounded, tips are regular and well filled. Grain is yellow and crinkle dented. This variety had not been grown to any great extent outside of Darke county until 1910, when it was tried in a number of the county variety tests.

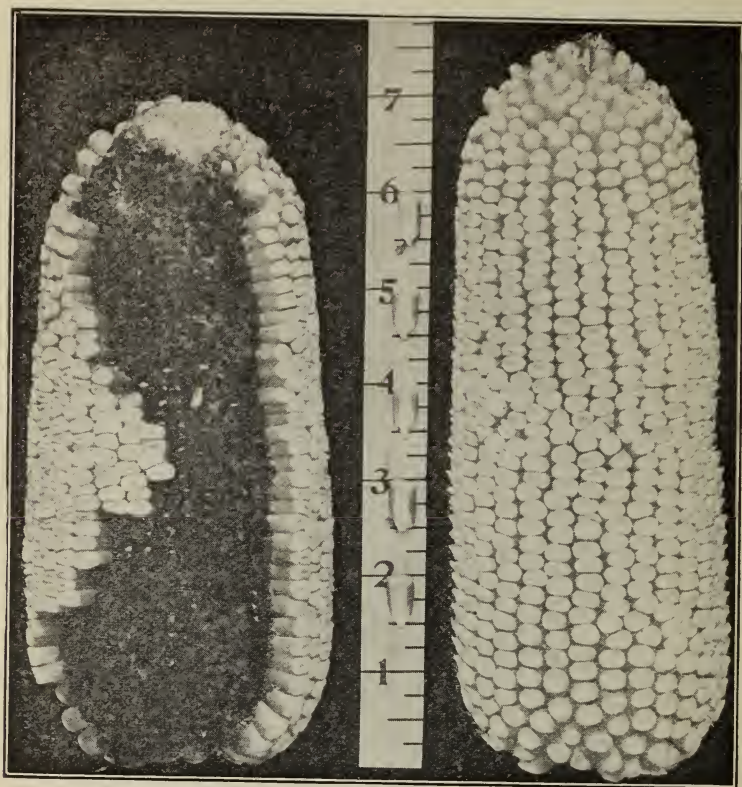


Fig. 13. Ears of Bear Paw corn

BEAR PAW CORN

The Bear Paw variety has been grown for many years by W. B. Turney, of Cadiz, Harrison county, but it was not reported in any other section of the state. The ears are 6 1-2 to 7 1-2 inches long, 9 to 9 1-2 inches in circumference, cylindrical, with 28 to 42 rows which are rather irregular, with narrow space. Butts are deeply rounding, tips irregular, cob very large and has two or more tips which give it the characteristic bear-paw shape. Kernels are 8-16 inch long, shoe-peg shaped, pale yellow and crinkle-dented.

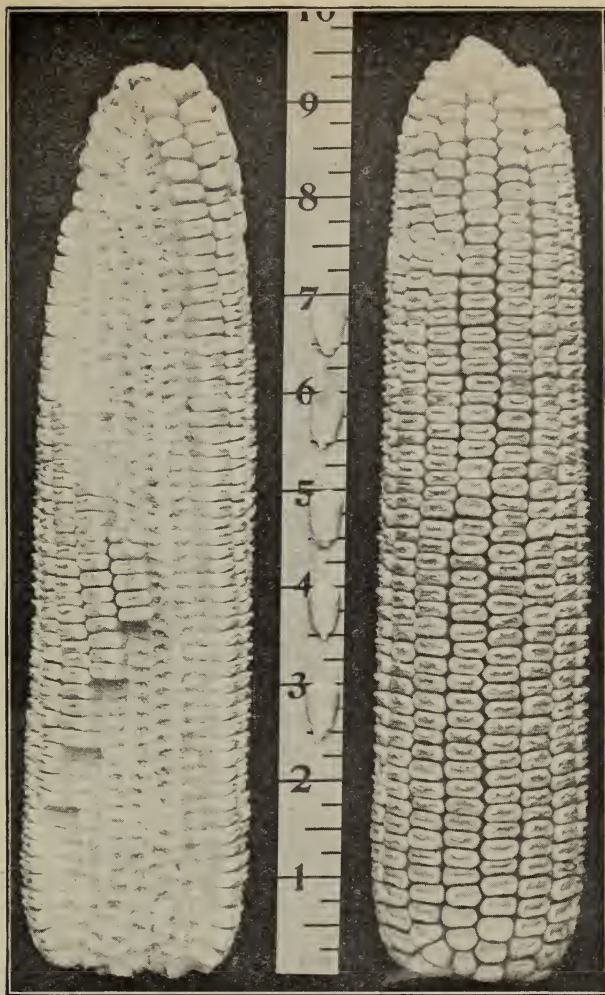


Fig. 14. Ears of Boone County White

BOONE COUNTY WHITE

Boone County White corn was originated by James Riley, of Boone county, Indiana, in 1876, by making selection from the White Mastodon corn. Mr. Riley endeavored to produce a variety that would ripen medium early in his locality. He also wished a high percent of grain.

The ears are 8 to 8 1-2 inches long, 7 1-2 to 8 inches in circumference, cylindrical, with 16 to 20 straight rows. Butts are rounded, tips are regular and well filled and spaces between the rows are

medium to close. Cobs are white and medium in size. Kernels are white and crinkle-dented to pinch-dented. It is grown mostly on river bottoms in southern Ohio, and on the best land in west-central Ohio.

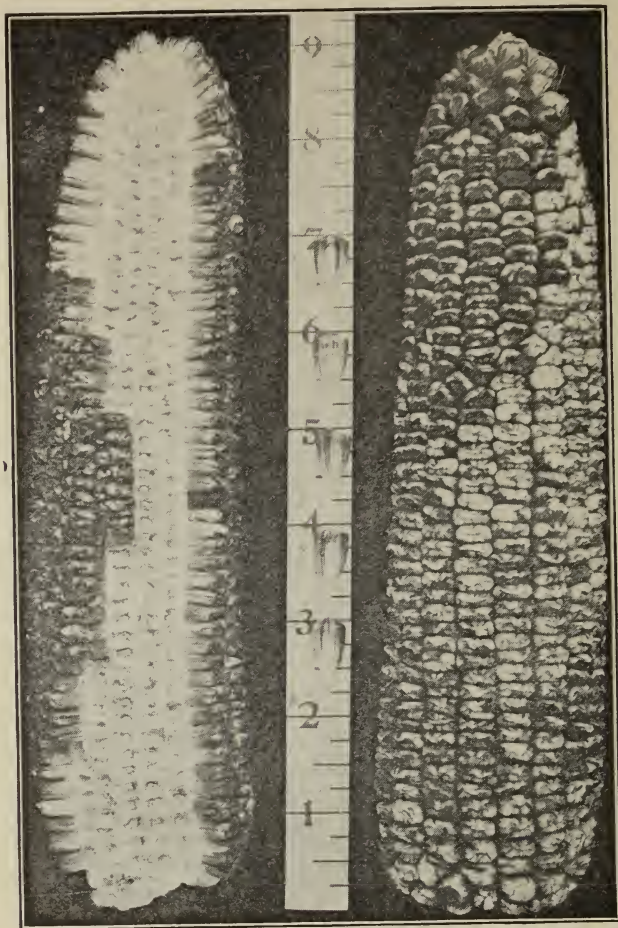


Fig. 15. Ears of Bloody Butcher corn

BLOODY BUTCHER

Bloody Butcher is a variety that takes its name from its color, which is a mixture of red and yellow, and like all varieties which take their name from one characteristic, its other characteristics may show a wide variation. It is medium early and has a very deep grain. It has local names in some sections. In Putnam and Van Wert counties a certain type of it is called Red Oak. In Clark,

Greene and Madison counties a strain of corn having this color is called Red River. This last is large and rather late in maturing. In other places in central Ohio the same general type of corn is called Red Feeding corn.

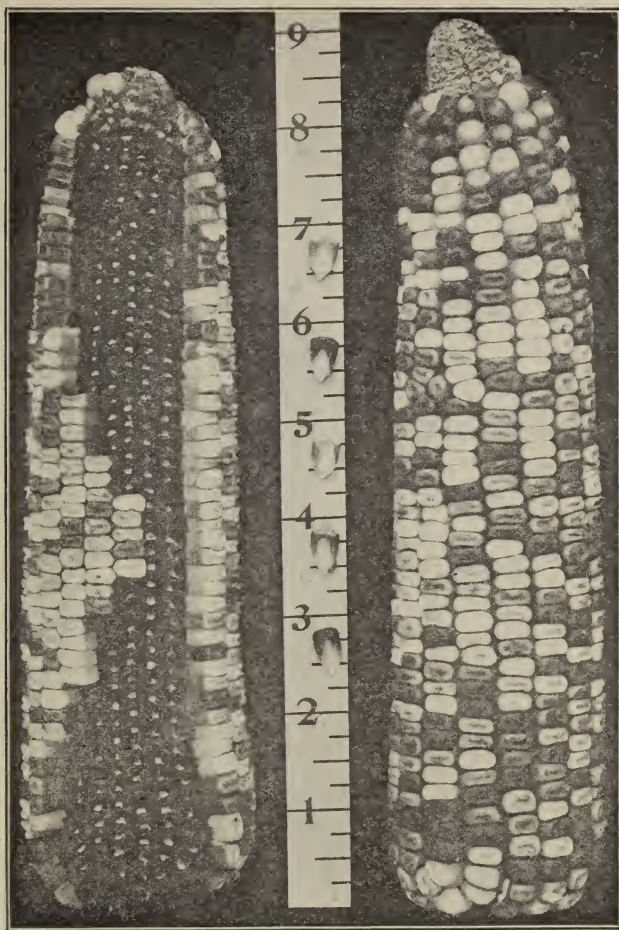


Fig. 16. Ears of Calico corn

CALICO CORN

Calico corn is another variety which takes its name from its peculiar color. It is a mixture of white and blue grains, although mixtures of red and white or red and yellow are also called Calico. The latter are, however, of the Bloody Butcher type. Calico is not grown to any great extent in Ohio and it has no fixed characteristics. It may be found in several counties in the northern part of the state.

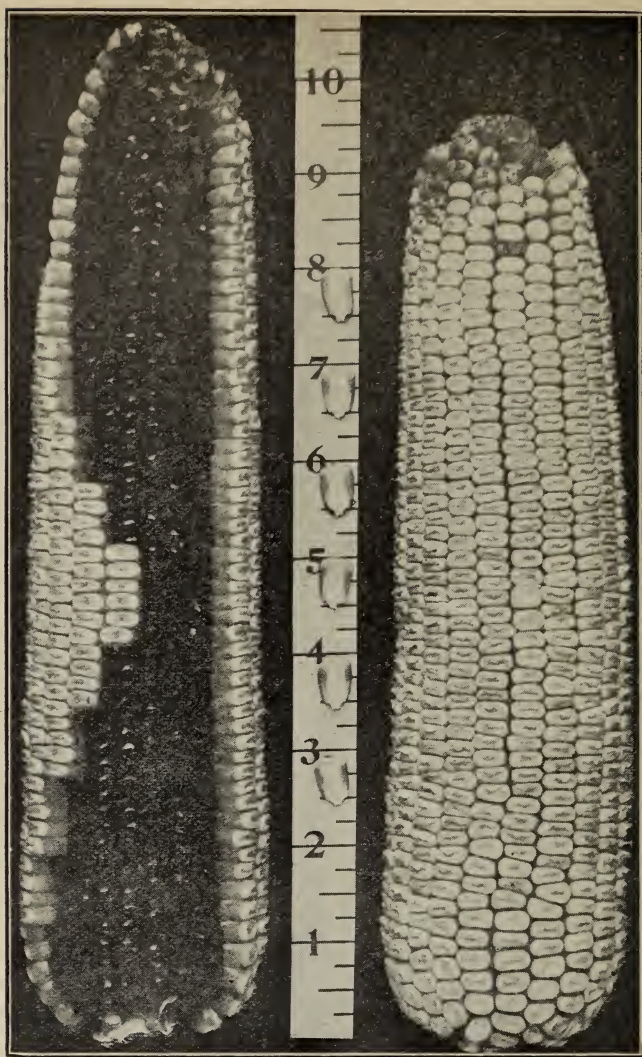


Fig. 17. Ears of Champion corn

CHAMPION CORN

The Champion variety is found in Van Wert county, where it is grown on some of the best corn land. The ears are 9 to 9 1-2 inches long, 7 inches in circumference, cylindrical, with 16 to 20 straight rows of grain, spaced medium close. Butts are moderately rounded and tips are regular and fairly well filled. Cobs are large, red in color. Kernels are yellow, 8-16 inch deep and crinkle-dented.

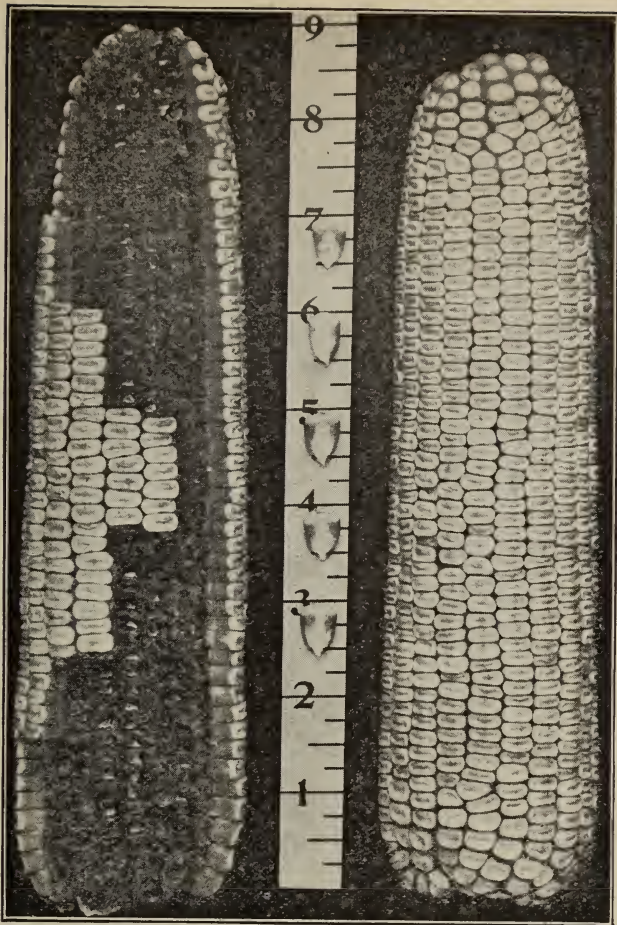


Fig. 18. Ears of Darke County Mammoth

DARKE COUNTY MAMMOTH

This variety was brought into Darke county from Columbiana county in 1883. About 1895 Mace & Mansfield, of Greenville, obtained it and through them it has been distributed over the western part of Ohio and the section of Indiana adjacent. It is considered a medium early variety in that section. When taken further north it is not safe to grow except under the most favorable conditions and can hardly be considered among the varieties adapted to the northeastern section.

The ears are 8 1-2 to 9 1-2 inches long, 7 1-2 inches in circumference and very cylindrical, with abruptly blunt tips and rounded

butts and 16 to 20 straight rows of grain running regularly clear to the tips, with close furrows. Grains are 8-16 inch deep, light yellow, crinkle-dented. The shank is medium-sized. Cob is large and red in color.

Poling's Yellow Dent and Hansberger's Golden Dent, both of which have a somewhat general resemblance to Darke County Mammoth, came from the same original stock.

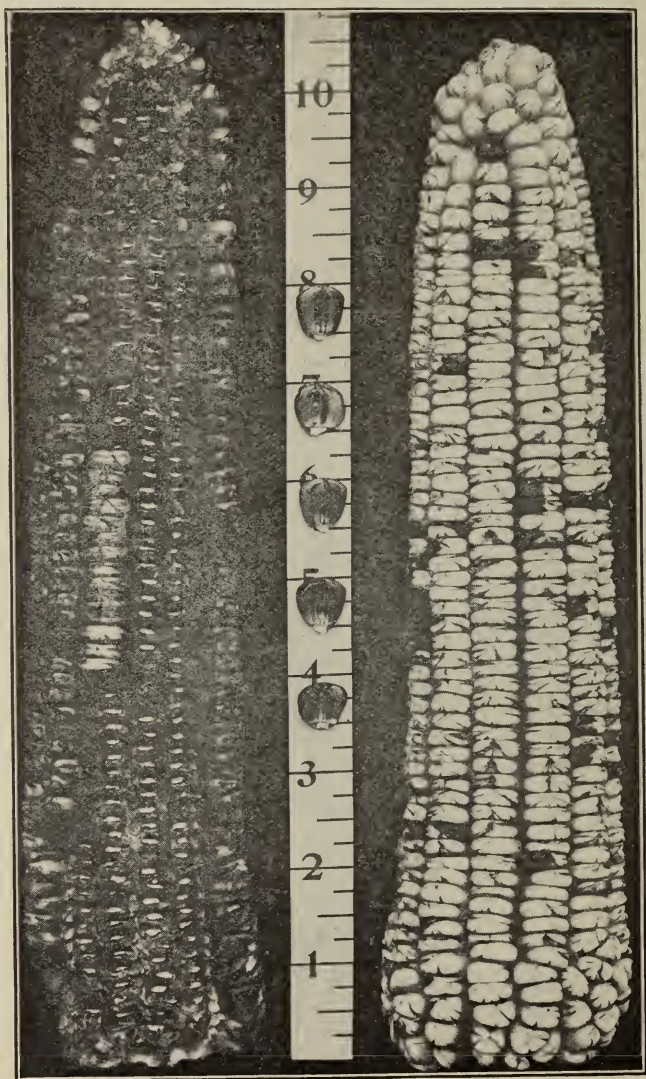


Fig. 19. Ears of Devolld corn

DEVOLLD CORN

The Devolld corn was originated by Levi Devolld, of Caldwell, Noble county, Ohio, about 1845. It is a mixture of a Bloody Butcher, a large white variety and a yellow variety of corn. Peter Devolld, his son, has chosen a trifle smoother type, otherwise the corn is similar to the type established by his father.

The ears are 8 to 10 inches long, 7 1-4 inches in circumference, very tapering, with 14 to 16 rows, spaced wide, with butts enlarged and flat and tips moderately well filled. Cobs are very large and usually red. Kernels are very large, broad and thick; red, white or blue with stripes of red lengthwise of the grain, with indentation either none or smooth. Some ears are almost solid red, some are nearly solid white and some have patches of red and white alternating. A large percent of the ears, however, are uniformly marked. This variety is grown only locally. It is not liked by many farmers for the reason, it is claimed, that it becomes extremely hard in summer.

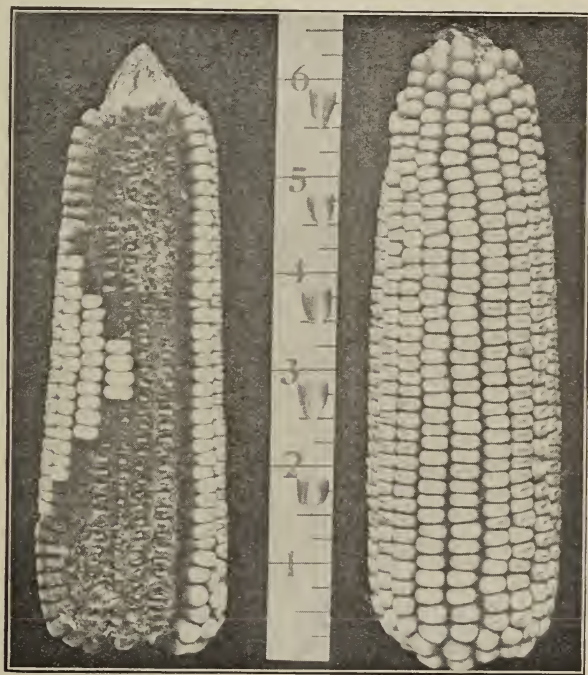


Fig. 20. Ears of Early Dent corn
EARLY DENT

Early Dent is a small early variety which has been grown in Summit county for years. It was taken there from Medina county, where it is reported to have been introduced from Indiana.

The ears of this variety are 6 to 7 inches long, 6 1-2 inches in circumference, slowly tapering, with 14 to 18 rows, medium spaced. Butts are rounding and tips are irregular and well filled. Cobs are small and red. Kernels are medium, wedge-shaped, 6-16 inch deep, yellow or amber, smooth or crinkle-dented. It is grown on hilly land when the season is short. Should be planted thicker than the larger varieties in order to get the best yield.

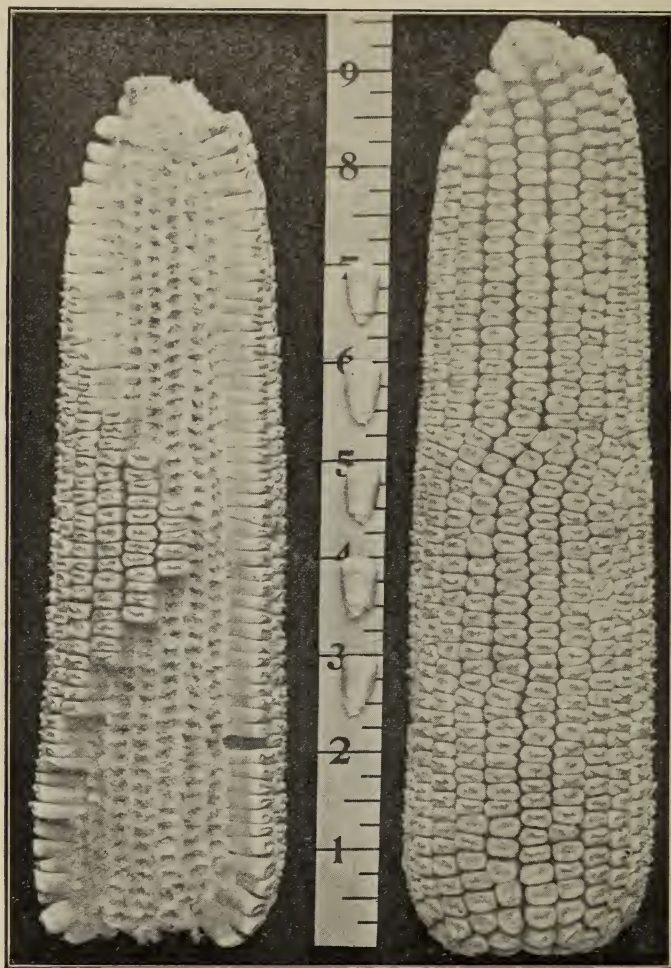


Fig. 21. Ears of Farmers' Interest

FARMERS' INTEREST

Farmers' Interest corn was distributed by J. A. Everett, a seedsmen at Indianapolis, Indiana. It has been grown on some of the best river bottom land in southern Ohio for a number of years.

W. E. Jeffries, Athens, Athens Co., Ohio, has been growing it for 11 years. Farmers' Pride, as grown by Dr. F. P. Ames, Rockland, Washington Co., is very similar and probably had the same origin. The ears are not quite so large and the indentation is somewhat smoother.

Farmers' Interest has ears 9 1-2 to 10 1-2 inches long, 8 inches in circumference, cylindrical, with 20 to 24 rows running straight along the ear, medium spaced. Butts are rounded and tips are regular and moderately filled. Cobs are large and white in color. Grains are 9-16 inch long, white in color and pinch-dented with a beak.

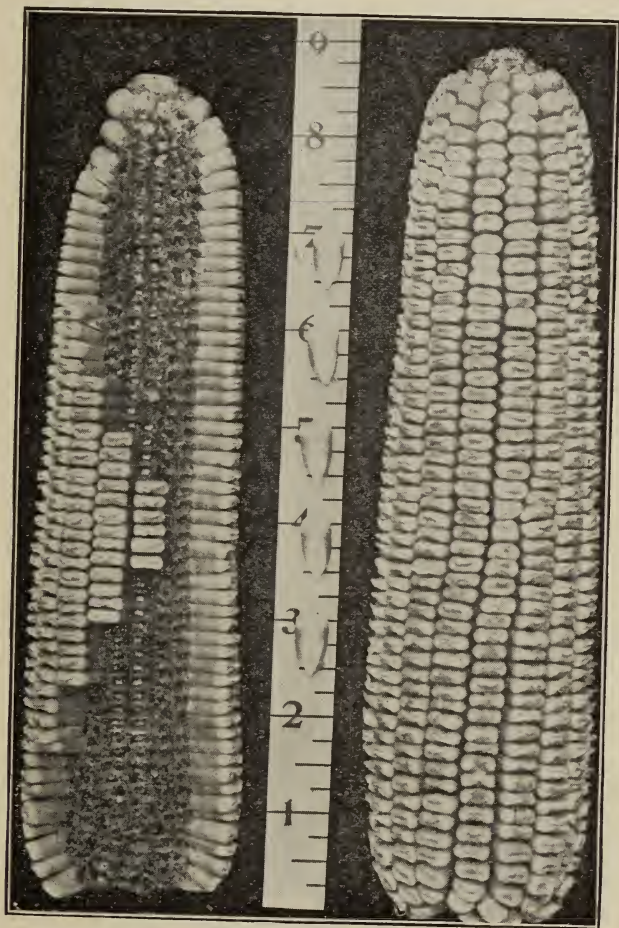


Fig. 22. Ears of Golden Surprise

GOLDEN SURPRISE

Golden Surprise is a hybrid corn originated by Simon Bell & Son, of Junction City, Perry county, Ohio, in 1890. One variety in

the cross was a small-eared amber-colored corn called Shoepeg, which had from 18 to 24 rows of small deep grains and was said to mature in about 50 days. The other was a pale yellow-colored variety which had 12 to 14 rows of very broad shallow grains and required about 130 days to mature. The last 16 years have been spent in trying to fix the type of the new variety by selection. Part of the ears each season are yellow and part show an amber color. At planting time each year 90 yellow ears and 10 amber-colored ears are shelled and mixed together in order to obtain the color desired by the originator.

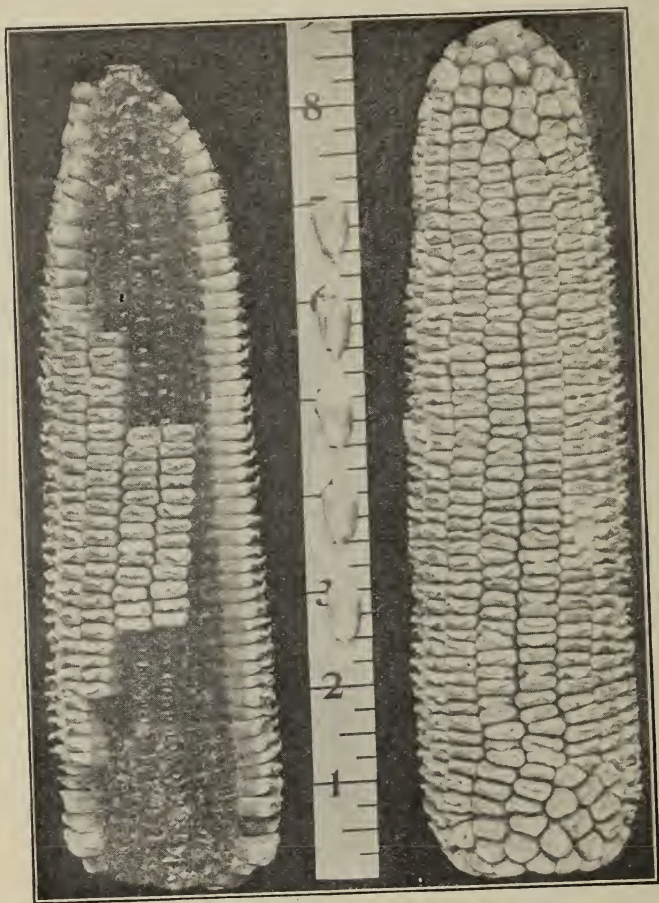


Fig. 23. Hackberry corn

The ears of Golden Surprise are 8 1-2 to 9 inches long, 7 inches in circumference, tapering gradually toward the tip, with 12 to 14 straight rows of grain, with wide spaces. Butts are well rounded

and tips are regular and not very well filled. Cobs are red and very small. The grains are 10-16 inch deep, of yellow or amber color, rather broad and pinch-dented with beak.

This corn has been distributed over the state to some extent, but is found mostly in the central portion. It is rather early in maturing but is not as heavy a yielder as some other varieties. It is specially noted for its high percent of grain.

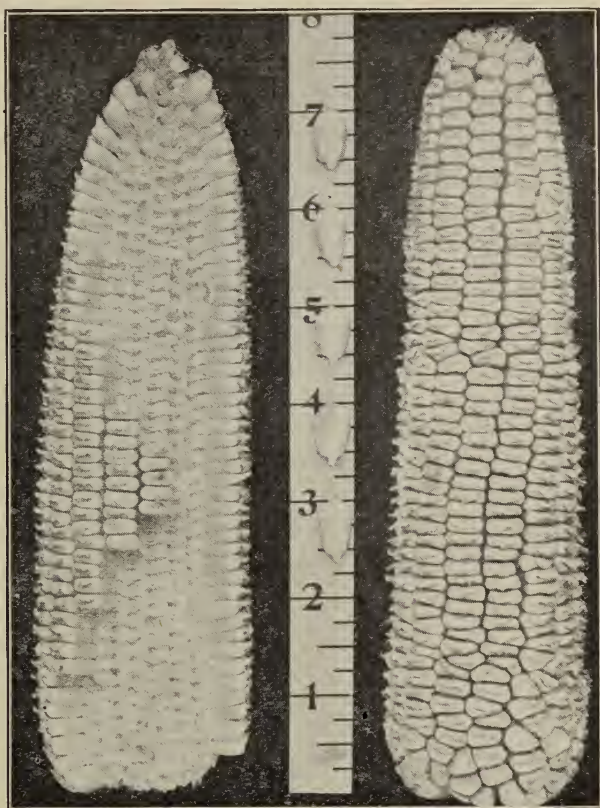


Fig. 24. Ears of Pebble Hackberry

HACKBERRY CORN

Hackberry is not a true variety but rather a selection of the rough ears from almost any variety. Occasionally a so-called Hackberry is found with which the process has been reversed and what was once a rough variety has now become a medium smooth variety.

The distinguishing characteristic, however, is the rough, chaffy tip on the grain. It is found in various parts of the state, but no great amount is grown anywhere.

PEBBLE HACKBERRY

The Pebble Hackberry is a small white variety having the Hackberry type of grain. It is grown on the upland in Pike county. The ears are 7 to 8 inches long, 6 1-2 inches in circumference, with 12 to 16 rows of grain, spaced wide. Butts are rounded and tips are regular and well filled. Cobs are white and small. Kernels are 9-16 inch long, pinch-dented with beak.

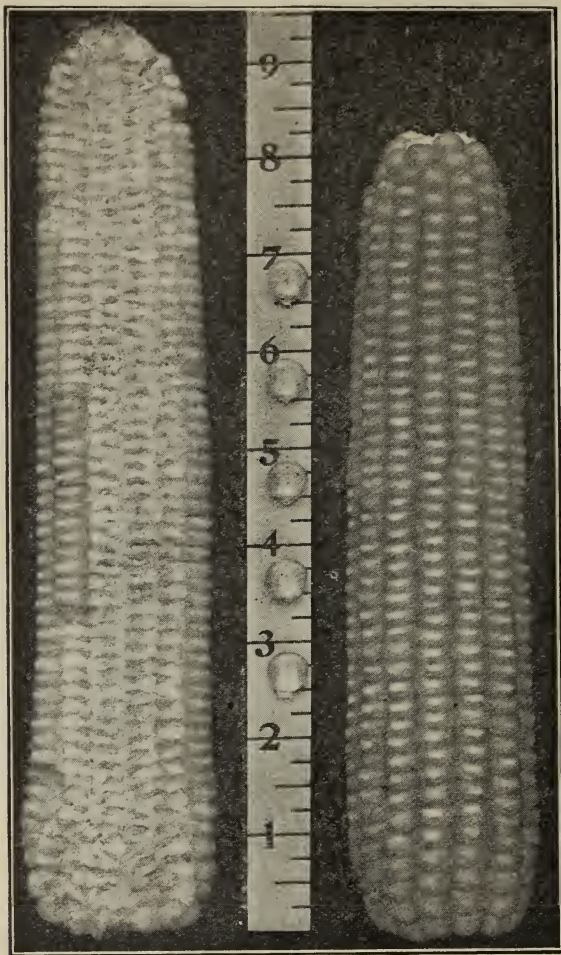


Fig. 25. Ears of Hominy corn

HOMINY CORN

This variety was produced by John Walford, Lancaster, Fairfield county, about 1860. He crossed a smooth white popcorn with a white dent variety. His aim was to obtain a variety suitable for hominy and white corn meal.

The ears of Hominy corn are 8 to 9 inches long, 6 inches in circumference, rather cylindrical but tapering slowly toward the tips, with 12 to 20 straight rows set close together. Butts are rounded and tips are regular and well filled. Cobs are white and medium-sized. Grains are 6-16 inch deep, pearly white and not dented.

This variety requires about the same season as the local dent varieties and yields about the same. It is grown only for hominy and corn meal and is found only in the vicinity of Lancaster.

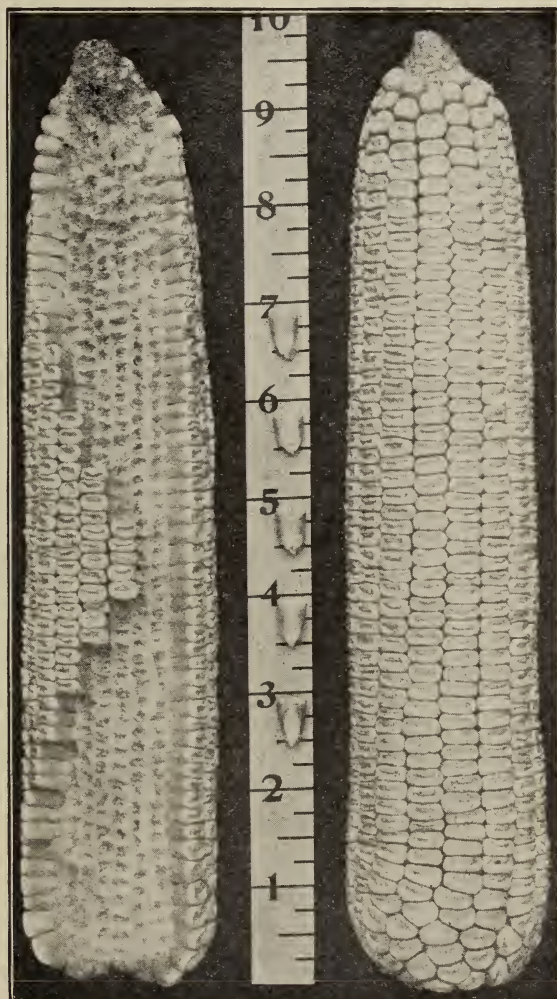


Fig. 26. Ears of McGinnis corn

McGINNIS CORN

Very little is known of the history of the McGinnis variety. The ears are 9 to 10 inches long, 5 3-4 inches in circumference, cylindrical, with 14 to 18 straight rows of grains, spaced close. Butts are rounded and tips regular and well filled. Cobs are small and red. The kernels are light yellow with a white cap, 7-16 inch deep, crinkle dented. It is found to a limited extent in Hardin, Logan, Van Wert and adjacent counties.

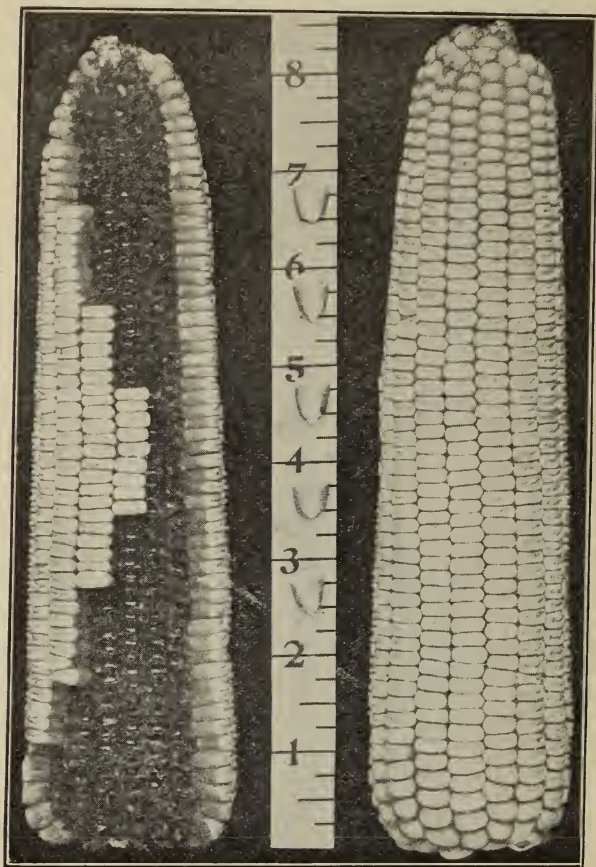


Fig. 27. Ears of Medina Pride

MEDINA PRIDE

Medina Pride was originated by C. B. Abbott, Chippewa Lake, Medina county, Ohio, about 1885. The stock from which it came was known locally as Kindig corn, an early maturing rather flinty-grained variety. By selection from this Mr. Abbott obtained an ear with a deeper grain and rows closer together, which does not mature quite so early.

The ears of this variety are 8 1-2 to 9 inches long, 6 1-4 to 6 1-2 inches in circumference and slightly tapering, with 14 to 18 rows, usually straight. Butts are rounded and tips are regular and well filled, with medium spaces. Cob is medium-sized and red. Grains are light yellow with medium-sized germ and crinkle-dented. It has been grown only in the northeastern part of the state. Probably not adapted to the remainder of the state.

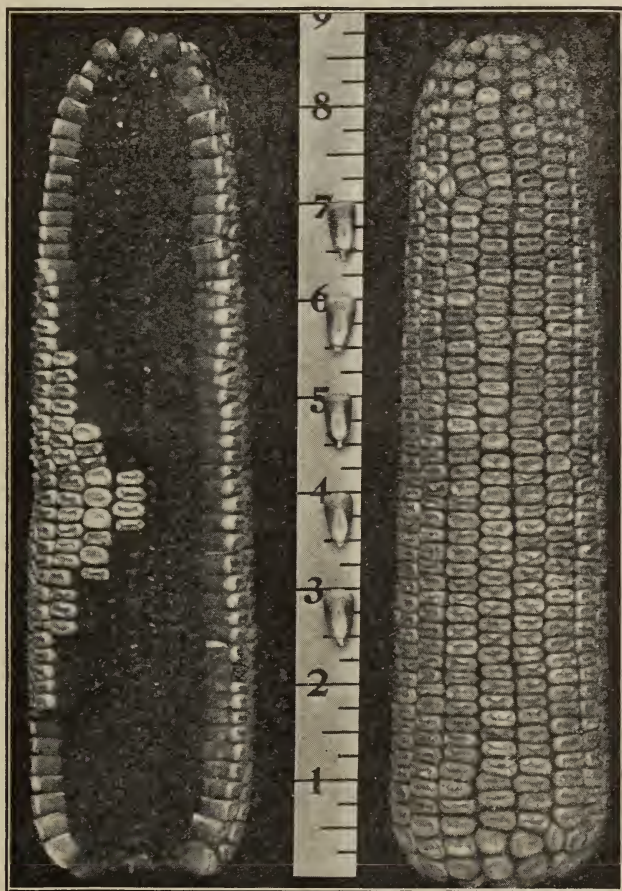


Fig. 28. Ears of Shroll's Yellow Dent corn

SHROLL'S YELLOW DENT

Shroll's Yellow Dent was originated by Harmon Shroll, of Kenton, Hardin county, Ohio, in 1898. It is a cross between Mortgage Lifter and a local variety called Kraus which bears a strong resemblance to Clarage.

The ears of Shroll's Yellow Dent are 8 to 9 inches long, 7 1-4 inches in circumference, with 16 to 20 straight rows, spaced close. Butts are rounded and tips are regular and well filled. Cobs are red and of medium size. Kernels are deep yellow in color, 8-16 inch deep and crinkle to pinch dented. It has become pretty well distributed over the county.

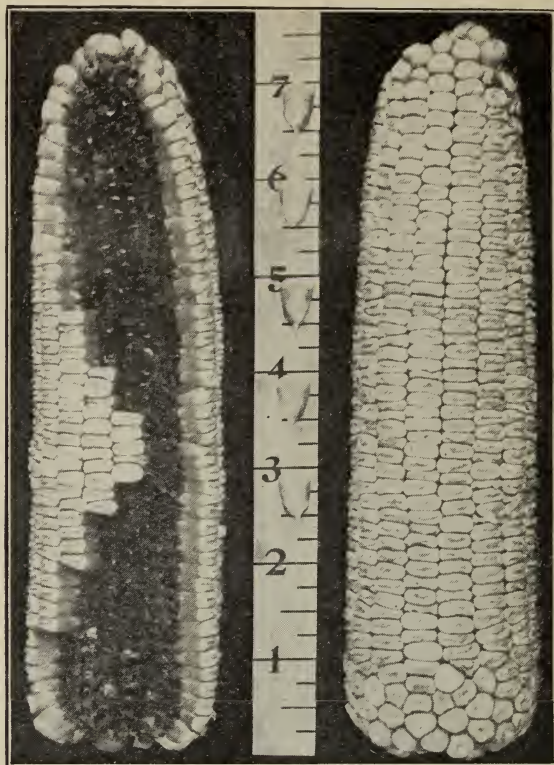


Fig. 29. Ears of Tawney's Yellow Dent

TAWNEY'S YELLOW DENT

Tawney's Yellow Dent is a small light yellow variety originated by the grandfather of the present grower, Philip Tawney of Marshallville, Wayne county, Ohio, about 76 years ago. It has been grown pure on the same farm ever since, but is not found anywhere except in the locality where it originated.

The ears are 7 to 7 1-2 inches long, 6 1-4 inches in circumference, tapering, with 14 to 18 rows of grain, spaced very close, with regular butts, moderately rounded and tips regular and well filled. Cob is medium sized and red in color. Kernels are light yellow, 7-16 inch deep, crinkle-dented.

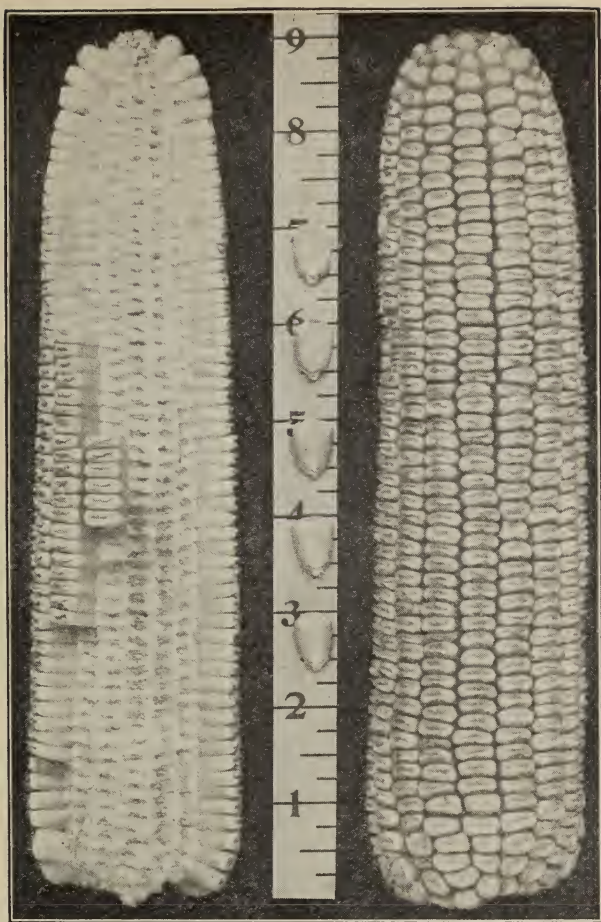


Fig. 30. Ears of Woodburn's White corn

WOODBURN'S WHITE

The variety known as Woodburn's White has been grown in Pike county on the bottom land along the Scioto river for many years by Judge J. M. Van Meter, of Piketon, Ohio. The U. S. Department of Agriculture has done considerable work with it under the name of U. S. D. A. No. 77.

The ears of this variety are 7 to 9 1-2 inches long and have circumference of 7 inches. They have 18 to 22 rows of grain running in straight rows and are slightly tapering with butts rounded and tips well filled. Cobs are white and of medium size. Grains are white, 8-16 inch deep and crinkle-dented.

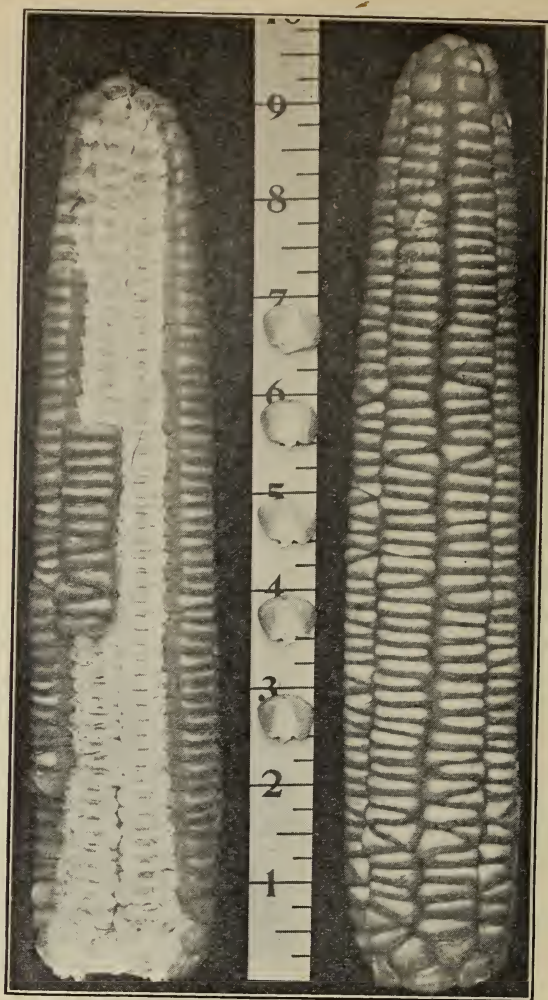


Fig. 31. Ears of Yellow Flint corn
YELLOW FLINT

This variety was introduced into Holmes county from Lancaster county, Pa., by Peter Somers about 1870. It has been much improved by Benjamin Weaver, of Mount Hope, especially in regard to filling at butts and tips.

The ears of this variety are 8 to 10 inches long and 6 inches in circumference. They are rather slender, like all flint varieties, cylindrical and have 8 straight rows of grains with open furrows. Butts are even, and tips are regular and fairly well filled. Cobs are white and small. Grains are yellow, 7-16 inch deep, very broad and with large germ.

The variety matures in 90 days. It should be planted thicker than dent corn, since it is inclined to sucker badly. The stover seems to cure rather slowly after the grain is ripe. This variety is grown quite largely on the hilly land in Holmes county, where it holds its own with the local dent varieties.

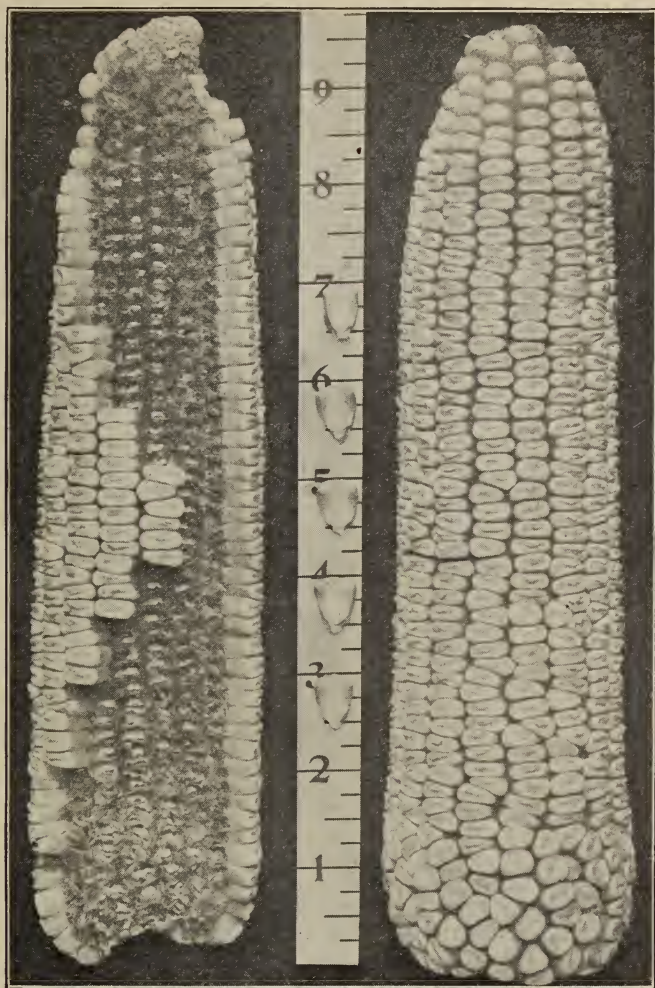


Fig. 32. Ears of Yellow Jumbo corn

YELLOW JUMBO

Yellow Jumbo is a large variety of corn that was originated by Ira L. Graham, of Payne, Paulding Co., Ohio, several years ago. It is a mixture of half a dozen varieties and Mr. Graham's object was

to secure a variety with as large ears as possible. On the rich soil of western Paulding county he was able to grow a very large-eared variety of corn.

The ears of this variety are 8 1-2 inches to 10 inches long, 8 inches in circumference, with 16 to 20 rows of grain, spaced medium. Butts are moderately rounded and tips are regular and moderately well filled. Cobs are large and red in color. Grains are medium wedge-shaped, 8-16 inch deep, crinkle dented, yellow in color.

The variety is grown on some of the best land in western Ohio, mainly in Paulding, Van Wert and the counties adjacent.

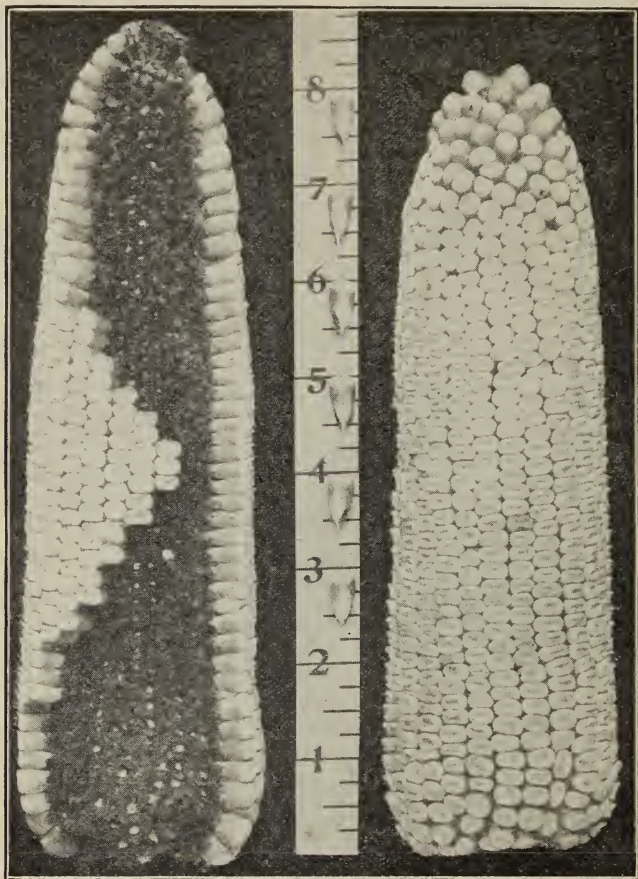


Fig. 33. Ears of Cuppy corn
CUPPY CORN

Cuppy, or Leaming Cuppy, as it is sometimes called, was originated about 1840, in Jefferson county near Steubenville by a Mr. Cuppy. An improved strain has been developed by P. C. Knisely, at New Philadelphia, Tuscarawas county.

The ears of Cuppy corn are 8 to 9 inches long, 7 3-4 inches in circumference, very tapering, with 20 to 24 medium spaced rows, part of which disappear towards the tip of the ear. Butts are rounded and expanded and tips are filled. Cobs are large at the butt, rapidly tapering, and red in color. Grains are rather small and 8-16 inch deep, smooth to crinkle-dented, yellow in color and with a white cap.

The general characteristics of the variety except color are very similar to Leaming, which probably was one parent in the cross. It is grown quite extensively on the river bottom land in Tuscarawas county.

WHITE CAPPED YELLOW DENT

White Capped Yellow Dent is not a variety. It would be just as correct to call all yellow varieties, that are dented, yellow dent. Almost any variety of white corn may be crossed with any variety of yellow and produce white capped yellow dent ears. Figure 34 shows one-ear samples representing the white cap corn grown by 26 farmers who live in all the sections of the state where this variety is produced. As may readily be seen, these ears conform to no standard or type in size or shape of ear, depth, shape or indentation of grain, or color of cob. The only thing they have in common is a yellow grain with a white cap.

LIST OF GROWERS OF WHITE CAPPED YELLOW DENT SHOWN IN FIG. 34

No.	Grower	Postoffice	County
1	Jas. Money	Berea	Cuyahoga
2	Eugene F. Cranz	Ira	Summit
3	L. A. Reed	Ravenna	Portage
4	A. G. Abbott	Wadsworth	Medina
5	J. A. Henry	Elkton	Columbiana
6	John D. Ramsey	Lisbon	Columbiana
7	James Pershing	Ragersville	Tuscarawas
8	Dr. McCullum	Uhrichsville	Tuscarawas
9	P. C. Knisely	New Philadelphia	Tuscarawas
10	W. H. Simpson	Freeport	Harrison
11	Wm. Chrisman	Bristol	Morgan
12	G. L. Fleming	Amesville	Athens
13	Souders		Williams
14	W. F. Sentele	Wauseon	Fulton
15	W. C. Dimmick	Bowling Green	Wood
16	Q. Seiple	Helena	Sandusky
17	Geo. F. Byall	Findlay	Hancock
18	Philip Schey	Leipsic	Putnam
19	W. A. Hatch	Kenton	Hardin
20	M. C. Mathews	Ada	Hardin
21	A. L. Stiffler	Prospect	Marion
22	A. L. Campbell	Cardington	Morrow
23	Chas. Butler	Pataskala	Licking
24	John P. Gandon	Sunbury	Delaware
25	Roy Kester	Celina	Mercer
26	Ward Swetland	Belle Center	Logan

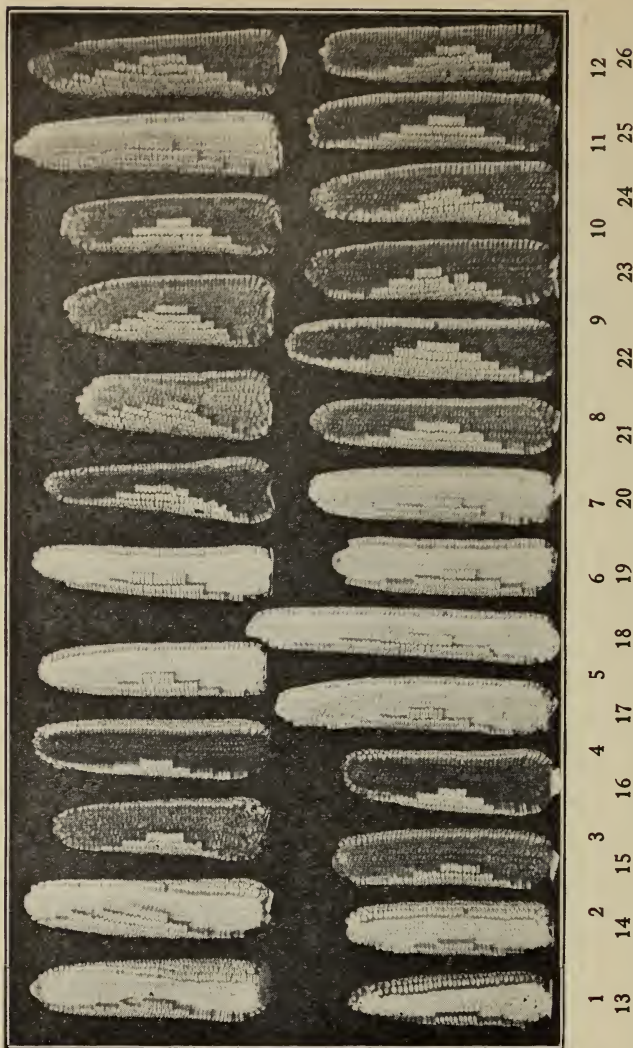


Fig. 34. Showing twenty-six different ears of White Capped Yellow Dent corn. Each ear represents the corn grown by a different man. The table on page 61 gives the name and postoffice of each farmer whose corn is represented.



Fig. 35. Map of Ohio showing comparative percents of White Capped Yellow Dent corn grown in 72 counties of the state.

TABLE I. SHOWING THE PERCENT OF SOME OF THE BETTER KNOWN VARIETIES OF CORN WHICH ARE GROWN IN EACH COUNTY,
AS DETERMINED FROM REPORTS BY FARMERS IN REPLY TO LETTER MENTIONED ON PAGE 23.

County	No. of reports	Average percent of each variety grown																	
		Leaming	Reid's Yellow Dent	Clarage	Darke Co. Mammoth	Golden Surprise	Yellow Jumbo	Boone Co. White	McGinnis	Silver Mine	Johnson Co. White	Bloody Butcher	Red Oak	Pride of the North	Farmers' Interest	Rotten Clarage	Baker's Early	Medina Pride	Champion
Allen.....	1	...	...	...	...	...	10	...	...	...	...	15	...	...	...	...	...	...	...
Ashland.....	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ashtabula.....	40	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Athens.....	25	...	...	...	...	...	...	...	...	...	...	...	5	50	...	...	...	...	...
Auglaize.....	1	...	...	...	...	...	5	S	S*	...	...	...	...	...	...	...	...	...	...
Belmont.....	55	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Brown.....	1	...	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Butler.....	10	10	10	S	...	...	...	...	...	...	6	...	...	...	5	...	...	...	...
Carroll.....	9	...	...	...	...	...	...	...	...	S	...	...	...	...	...	...	...	...	...
Champaign.....	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Clark.....	10	5	80	...	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...
Clinton.....	45	25	...	...	...	...	...	...	...	...	...	...	...	...	5	...	...	...	...
Clermont.....	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Columbiana.....	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Coshocton.....	20	S	...	...	...	...	...	...	...	...	...	...	S	...	...	...	...	...	...
Crawford.....	4	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cuyahoga.....	4	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Darke.....	11	10	5	...	20	15	...	...	...	...	...	...	...	...	...	10	...	...	...
Defiance.....	6	18	...	23	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Delaware.....	15	20	9	20	...	10	...	S	...	...	...	...	...	...	...	...	...	...	...
Erie.....	4	62	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fairfield.....	4	33	...	...	15	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fayette.....	7	...	...	10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Franklin.....	13	21	6	...	16	...	...	...	...	...	...	...	...	...	...	10	...	...	...
Fulton.....	6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gallia.....	8	13	15	...	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Greene.....	15	15	22	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Guernsey.....	12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Guernsey.....	50	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hardin.....	1	10	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hamilton.....	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hancock.....	3	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Harrison.....	5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Henry.....	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Highland.....	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hocking.....	20	30	28	...	...	...	...	S	...	...	...	...	...	...	...	...	...	...	...
Holmes.....	1	S	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

[illegible]

*Reports marked "S" indicate that the farmers reported "some."

There is a very strong popular belief in most sections where white cap corn is grown that it is better adapted to thin soil than yellow corn and that, if compelled to make its way against unfavorable conditions, it will give better yields of sound corn than will the yellow varieties.

If a line is drawn from A to B as per map in Figure 35 we find that the average percent of white cap corn per county south of the line is less than 5, while north of the line there is over 15 percent of that variety. Now draw another line from C to D dividing the north part of the state into north-west and north-east, and it will be noted that the north-west section has only 12 percent of white cap per county, whereas the north-east section has 20 percent. The conditions in northern Ohio are not as favorable to the production of corn as are those in the southern part of the state and the soil of north-western Ohio is far better adapted to corn growing than is that of the north-eastern section. This would indicate that in the main the poorer corn land sections actually grow the highest percent of white cap corn. That all strains of white cap are adapted to thin soil is not true, however, since Wing's White Cap and Leaming Cuppy have both been developed on far better than average soil.

WHITE AND YELLOW VARIETIES

With the state divided into northern and southern sections as per map in Fig. 35, we find from the reports previously mentioned that the north and south sections grow approximately equal amounts of yellow corn, the reports averaging 62.8 percent in the north and 63.8 percent in the south. The production of white corn, however, is much greater in the southern than in the northern section, the same reports showing only 10.7 percent in the north as against 22.2 percent in the south. If, however, we take the counties in the south which are composed largely of river bottom land or which grow most of their corn along a large stream; as for instance Butler, Warren and Montgomery along the Miami river, Scioto, Pike and Ross along the Scioto, and Gallia, Meigs and Athens along the Ohio, the reports show an average per county of 38.8 percent of the farmers growing white corn. Apparently the white varieties are, or at least are considered to be, not adapted to Ohio except on the best river bottom land in the southern part of the State.

CONCLUSIONS

1. Ohio has a large number of so-called varieties of corn.
2. The characteristics of Leaming corn are better known and it is more widely distributed over the state than any other variety.
3. White Capped Yellow Dent is not a variety but is a cross between any yellow dent and any white dent.
4. The sections of the state which are not naturally so well adapted to growing corn have more growers of White Capped Yellow Dent than those containing the best corn land.
5. The northern and southern sections of the state grow about the same percentages of yellow corn.
6. White corn is not grown to any large extent except on the river bottom land in the southern part of the state.

Ohio Agricultural Experiment Station

CIRCULAR No. 118

WOOSTER, OHIO, OCTOBER 9, 1911

FARM POULTRY

A COOPERATIVE INVESTIGATION OF THE PROFITABLENESS OF
POULTRY WHEN KEPT UNDER FARM CONDITIONS



CHAS. E. THORNE, *Director, Ohio Agricultural Experiment Station.*

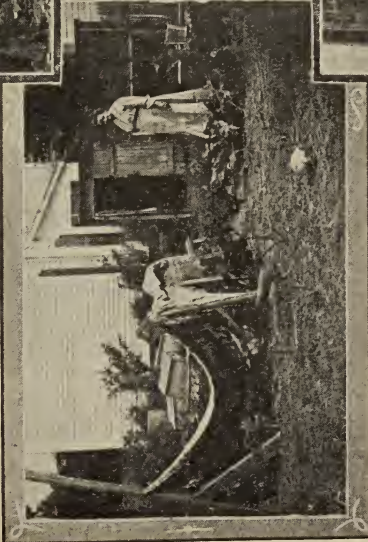
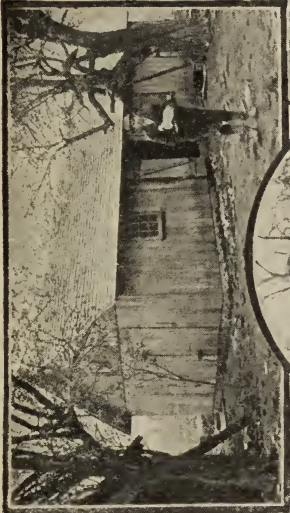
SIR: I have the honor to transmit herewith and to recommend for publication as a circular by the Experiment Station the accompanying manuscript entitled "Farm Poultry" which has been prepared by Mr. W. A. Lloyd and Mr. W. L. Elser, both of this Department.

Much difference of opinion seems to exist regarding the cost of production of poultry products on the farm. This paper is a preliminary report of a cooperative farm management investigation which it is hoped will shed light upon this subject.

Respectfully submitted,

L. H. GODDARD, *Chief, Department of Cooperation.*

Approved: CHAS. E. THORNE, *Director.*



THERE IS A DIFFERENCE

A PROFITABLE FLOCK

FLOCK No. 20
Number of fowls, 96

Inventory February 2, 1910	
Value of flock.....	\$ 48.00
Value of equipment.....	50.00
	\$ 98.00
Feed used.....	\$ 50.58
Labor.....	34.95
Supplies.....	1.75
<i>Amount to balance (profit)</i>	237.37
	\$422.65

Inventory February 2, 1911	
Value of flock.....	\$ 55.00
Value of equipment.....	45.00
	\$100.00
Eggs sold.....	\$234.43
Eggs used.....	10.37
Poultry sold.....	53.45
Poultry used.....	14.40
Manure.....	10.00
	\$422.65

AN UNPROFITABLE FLOCK

FLOCK No. 16
Number of fowls, 82

Inventory November, 1, 1909	
Value of flock.....	\$ 50.00
Value of equipment.....	42.30
	\$ 92.30
Feed used.....	65.46
Labor.....	49.98
Supplies.....	50.45
	\$258.19

Inventory October 31, 1910	
Value of flock.....	\$ 45.00
Value of equipment.....	84.70
	\$129.70
Eggs sold.....	45.51
Eggs used.....	10.44
Poultry sold.....	25.29
Poultry used.....	8.85
Manure.....	8.75
<i>Amount to balance (loss)</i>	29.65
	\$258.19

THE PARALLEL

FLOCK No. 20

Number of fowls, 96

Feed cost per fowl.....	\$.526
Labor cost per fowl.....	.364
Feed and labor cost per fowl.....	\$.89
Eggs produced.....	11,514
Eggs per hen.....	128
Average price per dozen.....	27.7c
Value eggs sold.....	\$ 234.43
Value poultry sold.....	53.45
<i>Total profit per fowl</i>	2.47

FLOCK No. 16

Number of fowls, 82

Feed cost per fowl.....	\$.798
Labor cost per fowl.....	.609
Feed and labor cost per fowl.....	\$ 1.407
Eggs produced.....	3,579
Eggs per hen.....	43
Average price per dozen.....	23c
Value eggs sold.....	\$ 45.51
Value poultry sold.....	25.29
<i>Total loss per fowl</i>	.36

THERE IS A REASON

FARM POULTRY

A COOPERATIVE INVESTIGATION ON THE PROFITABLENESS OF POULTRY WHEN KEPT UNDER FARM CONDITIONS

By W. A. LLOYD AND W. L. ELSEY

This investigation was begun in August, 1909, by the Department of Cooperation of the Experiment Station, with one cooperator. By the following February this number had increased to eighty-six, who were located in thirty-six counties of the State and represented widely varying phases of the poultry industry. The city-lot poultryman who kept his fowls penned throughout the year and who bought all his feed, the suburban resident with limited range, the farmer with unlimited range, and the commercial poultryman, were all represented. No strictly fancy poultrymen were included, though in a few cases a small number of fowls were sold for breeders and a few settings of eggs for hatching at more than market price.

OBJECT OF THE INVESTIGATION

Commercial concerns engaged in the manufacture of poultry appliances have written into their catalogs glowing accounts of the poultry business, and abstract statisticians have figured extraordinary profits. Certain "systems" have given wide publicity to the enormous returns that have been secured on a city lot. Other "systems" eliminate the necessity of the lot without decreasing the profit. The city man, influenced by abstract figuring of grossly exaggerated returns, looks upon the poultry business as a sure road to wealth and feels that the price he pays for poultry and eggs is little short of robbery, while the farmer frequently, if not usually, considers the flock as unprofitable. To use his own language, "they eat their heads off." Somewhere between the point of view assumed by the producer and felt by the consumer lies the truth. To ascertain this has been the object of this investigation.

No advice has been given to cooperators at any time as to methods of management relative to the housing, feeding or care of the flock; the object of the investigation being to study conditions as they exist, not to teach what they ought to be. Indeed, it is doubtful if very much in the way of advice is necessary to a person giving careful attention to the purely business end of an enterprise. He can hardly study *how* the enterprise is yielding for any very great length of time without discovering *why* it is yielding satisfactorily or otherwise.

Ohio Agricultural Experiment Station

DEPARTMENT OF COOPERATIVE EXPERIMENTS

FARM MANAGEMENT INVESTIGATIONS: POULTRY

In cooperation with

Name _____ P. O. _____

INVENTORY

Date _____ Taken by _____

Equipment	No. 1, 19			No. 2, 19			Stock	No. 1, 19		No. 2, 19	
	No.	Cost	Value	No.	Cost	Value		No.	Value	No.	Value
House No. 1							Chickens				
House No. 2							Hens				
House No. 3							Cocks				
Yard							Cockerels				
Fence							Pullets				
Water Fountain							Turkeys				
Feed Trough							Toms				
Self Feeders							Hens				
Shell Hoppers							Poults				
Nest Boxes							Geese				
Trap Nests							Geanders				
Nest Eggs							Geestings				
Bone Cutter							Ducks				
Vegetable Cutter							Drones				
Clover Cutter							Ducklings				
Feed Cooker							Guineas				
Grill Mortar							Peafowls				
Colony Houses							Pheasants				
Coops							Pigeons				
Brooders							Total Stock				
Incubators							Products	Am't.		Am't.	
Egg Tester							Eggs				
Thermometer							Feathers				
Punch							Manure				
Sprayer							Total Products				
Rong Syringe							Supplies	Am't.		Am't.	
Capacizing Set							Legbands				
Killing Knife							Cages				
							Crates				
							Disinfectant				
							Charcoal				
Total Equipment											
Feed											
							Total Supplies				
							Summary				
							Equipment				
							Feed				
							Stock				
							Products				
							Supplies				
							Total Summary				

The above list is intended to be suggestive rather than complete. No one will have all the articles mentioned, while all will probably have some not included. Include everything connected with the poultry. List stock at market value at time of taking the inventory.

Another blank with your Inventory No. 1 copied thereon will be sent you at the close of the year on which to make your Inventory No. 2.

Fig. 1. Inventory sheet

Ohio Agricultural Experiment Station
 Farm Measurement Investigations

Poultry Report for the month of

 April
 John R. Roe

 1911 Notes by
 J. E. Blankenship
 P. O.

Date	Number Quarters	Eggs Set	Eggs Incubated	Poultry Died	Larger Hens	Eggs				Miscellaneous	Remarks, Special Notes, etc.	Eggs Sold		Poultry Sold		Items		Miscellaneous	
						Kind	Value	Artificial	Value			No.	Value	No.	Value	No.	Value		No.	Value	Artificial	Value
1	31																		
2	32																		
3	30	#1																	
4	31	19																	
5	31																		
6	36																		
7	32																		
8	35																		
9	34																		
10	36	#2																	
11	31	150																	
12	34																		
13	39																		
14	38																		
15	32	#3																	
16	38	151/50																	
17	38																		
18	40																		
19	44																		
20	50	*																	
21	42																		
22	44																		
23	41																		
24	43																		
25	44																		
26	44																		
27	42																		
28	44																		
29	43																		
30	44																		
31																			
32																			
33																			
34																			
35																			
36																			
37																			
38																			
39																			
40																			
41																			
42																			
43																			
44																			
45																			
46																			
47																			
48																			
49																			
50																			
51																			
52																			
53																			
54																			
55																			
56																			
57																			
58																			
59																			
60																			
61																			
62																			
63																			
64																			
65																			
66																			
67																			
68																			
69																			
70																			
71																			
72																			
73																			
74																			
75																			
76																			
77																			
78																			
79																			
80																			
81																			
82																			
83																			
84																			
85																			
86																			
87																			
88																			
89																			
90																			
91																			
92																			
93																			
94																			
95																			
96																			
97																			
98																			
99																			
100																			

Fig. 2. Monthly Report sheet

PLAN OF THE EXPERIMENT

In conducting the experiment, each flock was inventoried at the beginning and again at the end of the year (see Figure 1) and each cooperator was furnished with a pad of 24 blanks, a reduced illustration of which is shown in Figure 2. Carbon sheets were furnished so that a copy of the report might be retained when the original was sent to the Station at the end of each month. The entries on these blanks in the illustrations are taken from the report of a flock and indicate the character of the information furnished. Each pad of blanks contained two summary blanks (see Figure 3) on which to carry forward the footings from the monthly records. One copy of the summary was sent to the Station at the end of the year, which was checked by the entries on the monthly sheet and a corrected copy was sent to the cooperator.

FEED AND LABOR

Only two requirements of the investigation presented any serious difficulties. Under farm conditions the feed for the poultry is usually taken from the bin or crib as needed; often with little heed as to the exact amount fed per day. Moreover, this is a chore that is frequently done by children or by the women of the household. To get accurate data as to the daily ration would have entailed extra work and often seriously changed the method of handling the flock, which would have destroyed the value of the test. To avoid this difficulty it was suggested that the feed for the poultry be periodically set aside in large quantities and charged against the flock in lump sums. Supplies of shells, grit, etc., were handled in the same way. The approximate ration fed was also given. It was, therefore, easy to check these figures pretty accurately. This method so simplified the feeding operations that very accurate and trustworthy data were secured in most cases. The labor record presented more difficulties. Several members of the family are frequently concerned with the care of the flock. A few minutes many times a day is given to the poultry. To get a near approximation of the amount of labor, each cooperator was asked to keep an exact account of the time consumed by the regular work incident to the poultry management for a period of two weeks, and to take the average of this as the amount of regular daily work. This average was based on the time it would take a man to do the work. If two little girls occupied two hours gathering eggs that could have been gathered by a man in 15 minutes, the latter amount was entered. Any extra work, such as repairing coops, marketing eggs, etc., was charged extra. The rate of man labor was based on the price paid

for common labor in the community of the cooperator. Each of the flocks included in the circular has been visited by the author and it is believed the results are accurate and trustworthy.

THE FLOCKS DESCRIBED

We believe the flocks visited represent a condition rather above than below the average of the community in which they were found. They are by no means the best and may probably be correctly said to present a fair average of those flocks which have received more than a passing interest. With regard to breed, the flocks classify as follows: American class, 16, represented by the following breeds: Rhode Island Reds 5, Barred Rocks 9, White Wyandottes 1, White Rocks 1. Mediterranean class, 9, made up of Brown Leghorns 5, White Leghorns 1, Buff Leghorns 2, and Black Minorcas 1. Asiatic class, 1, White Langshans; and mixed flocks, 4. In only three cases was any particular attention paid to standard requirements. The flocks were pure-bred rather than standard-bred. Nor could the four flocks classified as mixed be properly considered as mongrels.

While this investigation is not particularly concerned with a study of breeds or varieties, so much confusion among farmers exists with regard to the accepted terminology that it is well perhaps to get the distinction clearly in the mind.

(1) **Standard-bred poultry** consists of flocks bred to meet the breed and variety requirements of the American Poultry Association.

(2) **Pure-bred poultry** consists of flocks of distinct varieties without admixture of other blood, but in which no attention is given to the requirements of the standard.

(3) **Cross-bred poultry** consists of the progeny of two distinct varieties.

(4) **Mixed poultry** consists of flocks in which the females are made up of various varieties and crosses, but into which new blood is infused each year by the introduction of males secured from sources other than the home flock.

(5) **Mongrels or Dunghills** are fowls that are allowed to mate indiscriminately year after year, the males being selected from the home flock.

Referring to the above classification, it is probable that more than half of the chickens of the State are mixed; in point of number the other classes ranking as follows: Pure-breds, Standard-breds, Mongrels and Cross-breds, a very insignificant part of the poultry being in the last two classes.

The behavior of the different breeds as to egg production seems to be more a matter of care and feed than of breed. Of course, the individuality of the fowls enters quite largely into the matter, as the trap nest has repeatedly shown. As a general rule it may be said that the smaller, more active breeds are more prolific layers than the heavy breeds, while the intermediate breeds may be styled general purpose chickens, combining to some extent the laying tendencies of the lighter with the meat production of the heavier breeds.

In observing hundreds of flocks in all parts of the State, it may be said that as a general rule the Standard-bred and Pure-bred chickens are given much better care than the flocks of mixed fowls. The pride which the farmer has in a uniform flock whose breed type is to his particular fancy is accountable for this, and this better care is usually the key to the better performance. A uniform flock of poultry is a farm asset. It adds to the attractiveness of the home and to the value of the farm.



Fig. 4. A typical farm flock

THE RESULTS ANALYZED

Referring to the table on page 68, where flock No. 20 yields a net profit above feed and labor of \$237.37 or \$2.47 per fowl, in comparison with flock No. 16, which nets a loss of \$29.65 or 36c per fowl, a number of interesting phases of the poultry enterprise present themselves. The flocks were approximately the same size. Both

were pure-breds. There was no appreciable loss from disease in either flock; but the situations surrounding the flocks were entirely different. Flock No. 20 was situated in a purely rural community and had complete farm range. Flock No. 16 was in the suburbs of a small town and was kept in pens throughout the year. The feed cost per fowl is less in flock No. 20 by .272c than in flock No. 16, but this feed cost does not include kitchen, garden and orchard waste, farm gleanings, pasture, bugs, insects, worms, etc., which constituted a very considerable portion of the feed consumed by the fowls of flock No. 20, and of which flock No. 16 had but very little. The market price for eggs averaged 4.7c per dozen higher from flock No. 20 than from flock No. 16, occasioned by the product from flock No. 20 being sold to a private trade. The labor cost of flock No. 20 is less by .245c per fowl, occasioned by the different systems of management; but these variations do not make up for the wide difference that exists between the profit of \$2.47 per fowl and a loss of 36c per fowl. Where the difference is most striking is in the number of eggs per hen. An average of 128 eggs per hen from a flock of the size of flock No. 20 is certainly a very gratifying return, while 43 eggs, which is all that was secured from flock No 16, is decidedly unsatisfactory.

The individuality of the hens in flock No. 20 undoubtedly had something to do with the results, though no trapnesting had ever been done. It is quite possible, however, that if the two caretakers could have exchanged flocks, results would not have been greatly different. The system used by the manager of flock No. 16 was undoubtedly at fault, at least under his circumstances. However much an analysis of the figures may indicate, they can never tell the whole truth. To ascertain this we must look deeper. The low feed cost of flock No. 20 has been investigated and explained above, but it is in following the cue given us in the low labor cost that we strike pay dirt. This labor cost does not include the time spent "looking at" and "petting" the chickens by the flock mistress of flock No. 20. No more truly can it be said that "the eye of the master fattens the cattle" than that the coddling by the mistress helps fill the egg basket. It is not necessarily inferred that successful poultry husbandry is essentially a woman's business; but it is peculiarly true that success with poultry is intimately dependent upon close attention to a very large number of details; the doing of a large number of little things at the right time; and that the management of a poultry "system" requiring an excessive amount of care is not the part of a man with a number of other interests at stake.

The manager of flock No. 16, through the keeping of the records, has discovered his mistake and so changed the management of his

flock, that with a greatly reduced number of hens he is now gathering many more eggs than from the larger flock. Indeed, the egg yield per hen has more than doubled, and this year's work promises to yield him a very handsome profit.

TABLE 2. RESULTS FROM 18 FLOCKS KEPT ON FARMS

Flock No.	No. fowls	Eggs per hen	Value of equipment	Lab'r cost per fowl	Feed cost per fowl	Value eggs sold	Value poultry sold	Total cash receipts	Eggs used		Poultry used		Profit per fowl
									No.	Value	No.	Value	
1	110	72.4	\$ 25.22	39 c	60.7c	\$ 98.89	\$ 46.93	\$145.82	684	\$12.80	17	\$12.47	\$.70
2	115	86	101.75	23	55.5	112.78	21.77	134.55	1,501	25.01	18	9.20	.658
3	47	66	32.65	36	49	37.49	34.52	72.01	613	10.26	13	12.40	1.07
5	49	157	20.70	58	53.6	120.57	7.45	128.02	1,014	19.89	9	5.10	1.53
6	80	59.8	57.45	46	65	93.00	58.05	151.05	443	9.10	7	2.65	.83
10	83	76	187.75	37	78.3	66.70	47.50	114.20	1,632	31.79	45	29.75	.93
11	116	75	50.15	20	96	133.72	37.24	170.96	877	20.22	14	9.30	.63
12	309	81	159.00	24	58	217.39	105.22	322.61	2,511	41.35	86	31.10	.686
13	116	95.2	66.00	37	69.3	127.59	51.03	184.62	388	6.62	20	7.47	.673
15	93	78.8	31.70	15	35	80.09	19.18	99.27	1,374	21.66	10	4.55	1.54
17	95	91.3	25.00	33	58	88.73	20.82	109.55	956	20.25	25	21.35	.88
18	149	79	156.50	32	51	92.77	90.33	183.10	1,336	21.62	27	13.72	1.15
20	96	128	50.00	36.4	52.6	234.43	53.45	287.88	535	10.37	30	14.40	2.47
21	118	72	64.65	31	48	105.37	40.63	146.00	809	13.34	27	9.73	.623
22	46	60.4	20.00	23	55	50.89	20.37	71.26	806	12.70	28	8.30	1.04
25	150	71	75.00	24	55	159.47	14.65	174.12	1,713	26.61	106	39.60	.69
30	370	85	31.95	24	70	341.44	125.79	467.23	1,272	21.32	8	5.25	.753
31	38	66	25.60	40	56.2	19.13	26.84	45.97	552	8.60	14	11.44	.682
A v.	121	71	65.61	28	61	121.14	45.67	166.81	1,056	18.41	28	13.76	.87

TABLE 3. RESULTS FROM 12 TOWN FLOCKS AND 1 COMMERCIAL POULTRYMAN. FOWLS KEPT WHOLLY OR PARTIALLY CONFINED

Flock No.	No. fowls	Eggs per hen	Value of equipment	Lab'r cost per fowl	Feed cost per fowl	Value eggs sold	Value poultry sold	Total cash receipts	Eggs used		Poultry used		Profit or loss(-) per fowl
									No.	Value	No.	Value	
*4	333	141	\$401.50	.32	.81	\$733.86	\$ 77.57	\$811.43	722	\$14.15	29	\$ 8.35	\$1.46
7	87	126	58.00	.67	1.60	103.48	24.09	127.57	893	16.31	14	4.91	.56
8	24	145	65.70	.71	.84	22.05	1.50	23.55	592	12.10	19	13.53	1.10
9	30	53	171.45	1.60	1.27	4.77	9.25	14.02	965	19.32	39	20.87	— .93
14	26	128	14.50	1.57	1.45	24.29	89.20	113.49	1,004	19.50	14	8.95	1.64
16	82	43	42.30	.609	.798	45.51	25.29	70.80	612	10.44	20	8.85	— .36
19	97	103	74.43	.62	1.32	49.36	47.57	96.93	1,793	26.27	72	30.15	— .37
23	28	88	448.35	1.96	2.40	56.54	110.75	167.32	526	9.18	9	4.83	1.21
24	18	64	24.56	.34	.63	16.19	4.90	21.09	106	1.62	..	.....	.09
26	60	94	36.14	.36	.74	141.54	23.16	164.70	650	10.91	20	4.00	1.29
27	48	90	16.35	.35	.83	24.54	13.66	38.00	1,392	24.54	..	.....	.76
28	25	84	6.45	.66	1.17	2.50	1.00	3.50	1,872	39.91	24	13.25	.90
29	35	49	104.25	.52	.78	5.65	1.00	6.65	586	11.16	21	10.05	— .48
A v.	46	70	88.54	.60	.97	41.36	29.28	70.63	916	16.77	21	9.95	.36

*Commercial poultryman: not included in these averages.

Comparing these results with the whole number of flocks considered, we find:

18 farm flocks, average number of eggs per hen 71

12 town flocks, average number of eggs per hen..... 70

1 commercial poultryman,.....141

Average for all flocks,..... 76.5

SIZE OF FLOCK AND ITS RELATION TO PROFIT

Averaging the results from 31 completed records we find the average number of fowls per flock to be 99. Of these, 18 were farm flocks and 13 city-lot and suburban home flocks. The average size of the farm flock was 121 fowls, while the average of the town flock, excluding one purely commercial poultryman, was 46 fowls. Taking the average flock as the basis we find that we have the following profits per fowl:

Average profit per fowl in town flocks of more than 46.....	\$.26
Average profit per fowl in town flocks of less than 46.....	.44
Average of all flocks kept in town (i. e. wholly or partially confined)	.32
Average profit per fowl in farm flocks of more than 121.....	.63
Average profit per fowl in farm flocks of less than 121.....	.98
Average profit in farm flocks (i. e. complete range).....	.83
Average profit for all flocks.....	.84

The largest number of fowls kept in any town flock was 97 and the fewest 18. Four of the town flocks showed a loss. The greatest loss from a town flock was from flock No. 9, averaging a net loss of 93c per fowl. The greatest profit from a town flock was from flock No. 14, consisting of 26 fowls, averaging a net profit above feed and labor of \$1.64 per fowl.

None of the farm flocks showed a loss. The greatest profit was from flock No. 20 of 96 fowls, \$2.47 per fowl (see flock No. 20 on page 68). The least profit was from flock No. 18, of 149 fowls, 14.5c per fowl.

Three of the flocks exceeded 300 fowls, from which the average profit was 86c.

FEED COST

The average feed cost per fowl for the 13 town flocks was \$.97. Subdividing these into two classes, one of which had limited range and one of which had no range, we have:

8 flocks, no range, feed cost.....	\$.99
5 flocks, limited range, feed cost.....	.87
Difference.....	<u>\$.12</u>

Query: Does the difference represent the value of range (pasture) to a chicken?

Comparing again with the farm flocks, we have:

13 town flocks, feed cost per fowl.....	\$.97
18 farm flocks, feed cost per fowl.....	.61
Difference.....	<u>\$.36</u>

The farm flocks have a feed cost of 84 percent of the average in comparison with 134 percent for the town flocks. The great difference in favor of the farm flocks is attributable to a number of causes.

(1) **Gleanings:** (a) After the grain is cut the flocks gather large quantities of shattered grain from the ground that would otherwise be absolutely lost; (b) before harvest the flocks often "waste" a considerable amount of grain, also to some extent from the shocks and ricks when the fields are close to the farmstead. This is frequently a source of great aggravation to the farmer, and a principal reason for his considering poultry a "nuisance." It has cost labor and money to produce the crop and the quantity wasted, could it be determined, should be charged against the flock. However, is it "wasted"? When a field of rye or corn is hogged off it is not considered "wasted." The part eaten by the poultry, if it can be determined, should be charged against the flock, less the cost of harvesting, threshing and storing. Indeed, some poultrymen are sowing small fields or "patches" of grain close to the poultry yard and allowing the poultry to harvest it, considering it to be good poultry management to allow the fowls to get their feed in this manner. (c) Gleanings from the orchard and garden furnish another important food supply and largely one of pure credit to the flock, inasmuch as it saves what would otherwise be an absolute waste. A small amount of marketable fruit is damaged, and at times the fowls do some premature "gleaning" in the lettuce beds or flower garden which furnishes a juster source of aggravation than the gleanings from the ripening grain. The discriminating housewife, however, usually places the blame on the need of repairs to, or the total absence of, the garden fence. (d) The rejected cabbages, beets and other vegetables from the garden, if properly stored, constitute an excellent source of green food for use during the winter months. (e) The offal at butchering time constitutes a food supply that on many farms marks the time when the hens begin to lay. It probably calls attention to an illy-heeded admonition that an insufficient amount of animal food is being provided.

(2) **Pasture:** The pasture has been alluded to in a previous paragraph. Grass is a natural and very important part of a poultry ration. Any other form of green food is a substitute for it. The grass consumed by the poultry constitutes a just but as yet undetermined charge against the farm flock. The amount before suggested, 12c per hen per year, may be too high or it may not be high enough. It is suggested only as an indication and as a subject of future study.

(3) **Weed seeds and insects:** This constitutes a direct overhead credit of undetermined value. The countless thousands of insects, worms and weed seeds destroyed by the fowls during the summer help to restore the balance man has destroyed

by the slaughter of the wild birds; and they are also an important food supply. One farmer reports that the chickens by following the plow in the furrow and catching the grubs and cutworms saved his corn crop.

(4) **Dairy by-product:** Skim milk, separator milk and curds are largely used in the country as poultry foods. They afford a splendid addition to the ration and one much relished by the poultry. This by-product of the dairy has a money value and should be charged against the flock. However, it is a cheap source of food not usually available to the city poultryman.

(5) **Difference in actual cost of grain consumed:** The feed that has been produced on the farm and is consumed by the poultry is charged against the flock at the current price paid at the elevator or feed store or mill, less the cost of marketing, while the town poultryman usually buys in small quantities from the local merchant at a very greatly increased price.

LABOR COST

The difference in labor cost between the town and the farm flocks is also significant, largely from the enforced difference in management. Comparing the different situations we find:

18 farm flocks, labor cost per fowl.....	\$.28
12 town flocks, labor cost per fowl.....	.60
1 commercial poultryman.....	.32
Average of all flocks.....	.37

The above difference is largely due to the disadvantage of the flocks kept wholly or partly confined. It may often happen, however, that the labor incident to the care of the town flocks has its recompense in a little work in the open, a better circulation, a better digestion and a more wholesome outlook, and withal, in the pleasure of having for the table a clean, wholesome product that is the work of one's own hands. Such a consummation may easily make up for any lessening of profits or even for a loss.

INCOME

The two important sources of income from poultry are from the sale of eggs and from the sale of poultry. From the 31 flocks considered the results are as follows:

Income from 31 flocks	Average per flock		Total
	Sale of eggs	Sale of poultry	
18 farm flocks.....	\$121.14	\$45.67	\$166.81
12 town flocks.....	41.36	29.28	70.64
1 commercial poultryman....	733.86	77.57	811.43
Average of all flocks.....	110.03	40.34	150.37

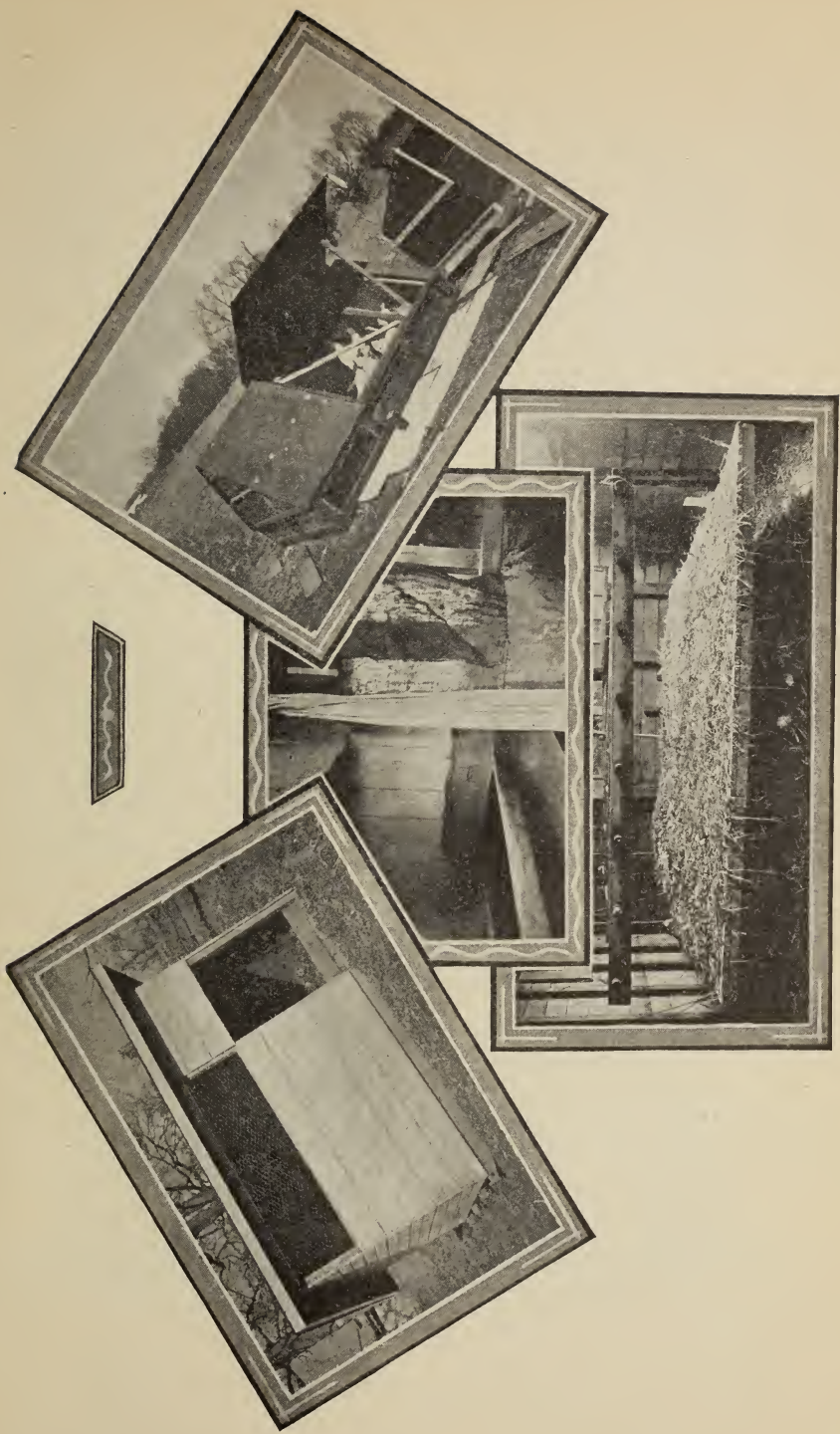


Fig. 5. Some poultry conveniences

Eggs are by far the most important source of income, being 73 percent of the total. Other minor sources of income are: (1) **Feathers.** There is a good demand for properly cared for chicken feathers, though the amount secured under usual farm practice is necessarily very small. They are not usually saved. (2) **Manure.** Poultry manure is a highly variable product; its fertilizing value being dependent upon both the kind of feed consumed by the fowls and the method of caring for the product. If the flock is fed liberally of meat scraps, cut bone and other nitrogenous feeds, the droppings will contain a much higher percent of nitrogen than if grain feeds only are used. It is a very common practice to distribute air-slacked lime liberally in the poultry house under the roosts. This practice is commendable from a sanitary standpoint, but the value of the manure is decreased by the consequent lowering of the nitrogen content. Gypsum, floats or acid phosphate are good substitutes for the air-slacked lime. Analyses of poultry manure differ greatly. Professor Storer in his "Agriculture in some of its relations with chemistry," gives this conservative analysis: water 56 percent, nitrogen 1.6 percent, phosphoric acid 1.5 percent, potash 0.8 percent. At present prices of the chemical ingredients this would warrant a valuation of \$5.22 per ton. The New Hampshire Station, in its Annual Report of 1908, reports that the roost droppings from 25 hens for the 6 winter months amounted to 375 pounds. On this basis each hen produces 30 pounds of manure annually and 100 hens should be credited with an amount equivalent to 250 pounds sulphate of ammonia, 300 pounds phosphoric acid and 200 lbs. kainit, if the manure were all saved and properly cared for. Under prevailing systems of poultry management much of the value of the roost droppings is lost, while a large percent of the range droppings is of little manurial value from being deposited where not needed. Poultry manure is an ideal dressing for grass. Not a little of the excellence of herbage in the orchards, when fowls are given the run of it, is to be attributed to the manure from the farm flock.

EQUIPMENT

In the 31 flocks considered the equipment value varies from \$6.45 to \$448.35, the average for all the flocks being \$89.11. The average of the town flocks was somewhat in excess of the farm flocks.

18 farm flocks, average value of equipment.....	\$ 65.61
12 town flocks, average value of equipment.....	88.54
1 commercial poultryman, value of equipment.....	401.50
Average of all flocks.....	\$ 85.32

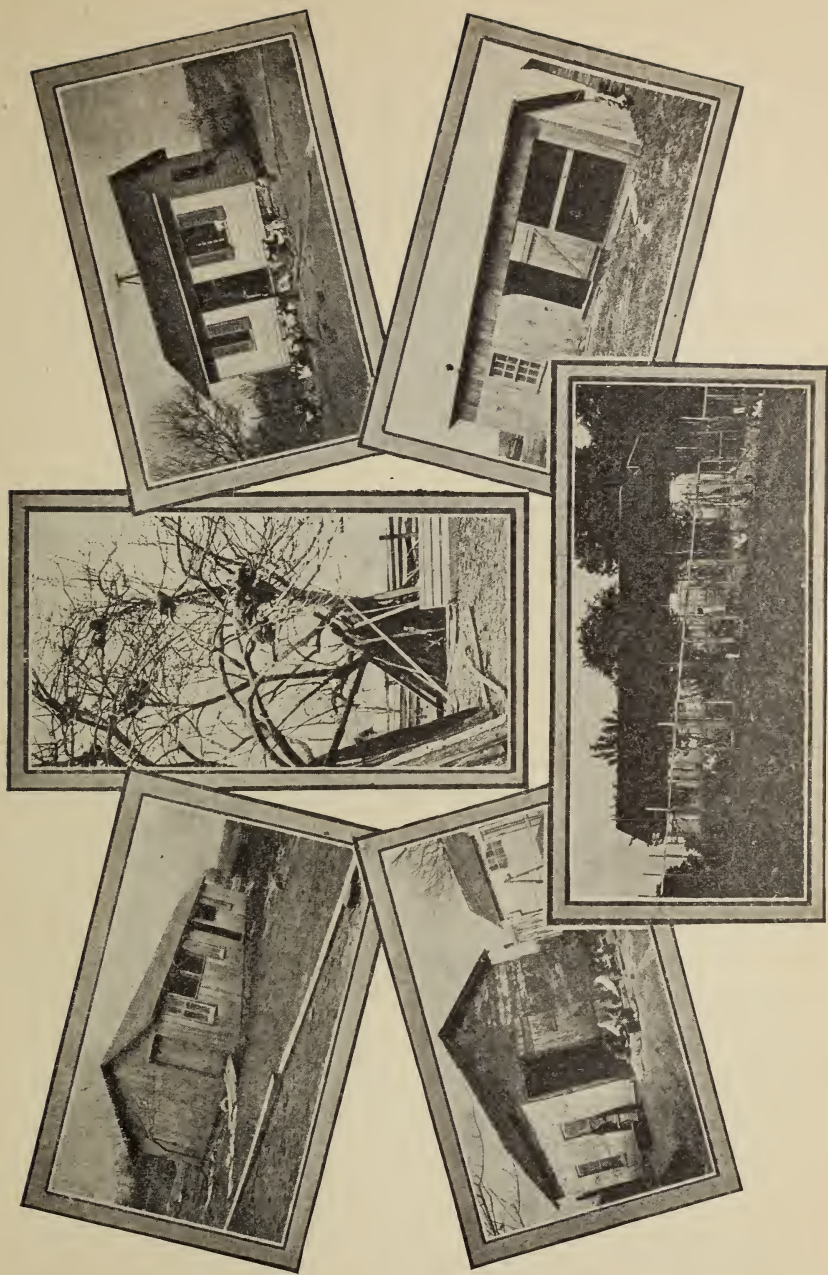


Fig. 6. Some poultry houses

On the basis of number of fowls kept the average value of equipment per fowl was 86c, the town value being \$1.63 and the farm value 54c. A great improvement is noticeable in the character of poultry equipment over that of a few years ago. However, the old apple tree at the corner of the barn is still occasionally utilized.

MARKETING

The eggs and fowls of the flocks considered were marketed in various ways, some selling direct to private customers during all or a part of the year, some selling to the local store for cash or trade, some to hucksters at the door and some shipping to the city market.

Ordinarily, eggs or poultry from the farm flocks are marketed at the country store for trade or for cash, or during the summer months are disposed of to the huckster in exchange for his wares at the door. Those living in or near town sometimes sell to a select family trade at an advance of four to five cents above the market or store price. This practice is not nearly so common as it should be.

The difference in the retail buying and selling price in most small towns varies from two to five cents per dozen, the surplus eggs going to the local egg merchant or commission man or to storage, frequently at lower prices than were paid for them to the producer. This arises from the fact that the general merchants handle country produce (butter and eggs) for the business it brings to their stores, making their profit on the goods sold. There is frequently a trade price at from one to two cents per dozen of eggs above what is paid in cash, while in some localities of the state cash is not paid at all, but due-bills or "script," as it is termed, is given for what is not traded out at the time; the eggs in this case passing for money. These various ways of disposing of the product account for the wide variation in the price received for eggs, as shown by the table below. This table shows the average of all the flocks considered for each month from December 1909 to January 1911.

An examination of the table discloses that for all the flocks considered for the period covered by the investigation, the farmer received for his eggs within one-tenth of a cent per dozen of the average Cleveland wholesale price for "current receipts." Manifestly, the country merchant must have looked elsewhere for his profits than to the egg trade. Indeed, in some months the average farm price was in excess of the wholesale Cleveland price, notably in December of 1909: average farm price, 33.8c. Cleveland wholesale price for "current receipts," 32c. The same condition existed in May, June, July, August and December, 1910. The average Cleveland retail price for eggs exceeded the farm price by 4.3c, and the fancy price exceeded it by 9.6c. The lowest Cleveland retail price

was 23c during the month of July and the highest Cleveland retail price was 55c during the month of January, 1910. The lowest farm price was 15c during March, 1910, and the highest farm price was 43.5c during December, 1910. These figures are influenced slightly by the few who sold to private parties. Excluding these and taking the average of those who sold to the store, we find the average retail price to be 24.7c, which is only 1.3c less than the average Cleveland wholesale price for "current receipts."

Period covered by investigation	Cleveland price Retail Cts. per doz.		Cleveland price Wholesale Cts. per doz.		Farm price Cts. per doz.			Average Ohio price 1910* Cts. per doz.
	Fancy	Fresh	Current Receipts	Storage	Maximum	Minimum	Av.	
December, 1909.....	45	35	32	....	35	31	33.8	30
January, 1910.....	48.3	36	34.1	25.1	37.5	28.5	31.7	31
February.....	37.3	32	28	24.5	40	21	27.5	31
March.....	36.7	29.2	23.1	....	33	15.5	22.3	24
April.....	28.5	26	21	....	23	18	19.7	19
May.....	27	24	20	....	25.5	17.5	20.3	19
June.....	27	24	19.5	....	26	17	20.4	19
July.....	26.7	23.7	18.7	....	25	16	19.4	19
August.....	27	24	19.6	....	25	17	22	19
September.....	29.7	26.5	22.5	....	33	18	22.4	20
October.....	34	30	25.6	....	32	20	25.2	23
November.....	38.3	34	30	....	40	20	30.1	26
December.....	48	40	35.8	24.5	43.5	32	36.6	31
January, 1911.....	44	39	35	25	39	20	32.5	....
Mean for period....	35.5	30.2	26	24.7	....	....	25.9	....
Mean for 1910.....	34	29	24.8	....	....	...	24.8	23.4

*Year Book 1910, U. S. D. A.



Fig. 7. Commercial poultry plant

THE EGG TRADE

After the eggs leave the producer they travel a long and very devious way before they reach the consumer. The country merchant buys eggs from the producer without regard to kind, color or condition, excluding only checks; i. e., eggs that are broken in bringing to market. He usually sells the eggs which he buys in the same way; i. e., "case count" to the produce man or shipper who usually "candles" the eggs; i. e., grades them in a dark room before an egg candle, into firsts, seconds, dirties, checks, rottens, etc. He in turn disposes of these grades in various ways. During the months of heavy production he may send large quantities of his best eggs to storage on his own account, or he may sell them to the storage houses. He may ship to hotel trade or to commission men or to the retail trade. The produce men usually handle eggs from several counties and ship in car lots. The commission men frequently recandle the eggs and grade them to meet the requirements of their particular trade, a not infrequent route from producer to consumer being the general store, produce men, storage house, wholesale house and retailer.

Eggs gathered from the farm are usually marketed once a week or oftener, though they are sometimes held for a longer period for an increase in market price. There is no incentive to take any particular pains in caring for the eggs marketed, as the general store makes no distinction. The general store makes shipments weekly or oftener, according to the supply and market conditions. After reaching the produce men the eggs are handled as rapidly as possible until in storage or in the hands of the retailer. The terms "fresh," "fancy," "No. 1," "storage," etc., of the retail trade are purely trade terms and do not indicate much with regard to the "freshness" of the product. Indeed, only the poorest grade of storage eggs are usually sold as such. This practice is unfair to the producer, to the consumer and to the storage business. It is unfair to the producer inasmuch as it makes use of terms intended to convey the idea that the product is received directly from him, and his product is made to suffer by reason of any delinquency of the counterfeit. It is unfair to the consumer inasmuch as it deceives him as to the quality of the product he is buying, and is unfair to the storage business inasmuch as the public judges the quality of storage eggs only by the poorest eggs of this class.

A better and more rational system of marketing eggs is needed; a system that will place this most wholesome food product in the hands of the consumer with the least possible delay and in the best possible condition. Particularly to be desired is the elimination of

the present practice of handling of eggs by the general stores. Manifestly the general store-keepers cannot buy the eggs offered in any other way than that in which they do. The country merchant is after business for his store and he dare not offend a patron by refusing what is offered, lest competitors secure the offended customer. His method encourages careless, slovenly habits in caring for the eggs by the producer. He encourages holding the eggs until a quantity can be brought to the store at a time and is himself guilty of storing the eggs in damp, foul-smelling cellars, resulting in mouldy, shrunken eggs of low quality.

Through the present method of marketing, the producer not only bears the brunt of his own sins but he bears as well all those that have attached themselves to his product on the long route between him and the ultimate consumer. It might seem that under the present system the producer is faring very well, considering, as this investigation shows, that he is receiving practically as much for his product at his local store as it brings after it passes through three or four hands and is transported to a distant market. But this advantage is more apparent than real. The farmer who trades his eggs at the country store for goods at a trading price in excess of what the merchant can get for these eggs after shipping them to market, should know that the price he is receiving for his product is an artificial one and that the merchant gets the same percent on the goods he sells whether he pays 16c or 22c a dozen for the eggs.

But the most serious objection to the present system of handling eggs is that the price paid for them, being to a great extent a reflex of the demand, is directly influenced by the low quality of the offering. The consumer who gets a poor quality of eggs from his grocer usually buys something else the next time he goes marketing and so lessens the demand and decreases the price. Thus the producer suffers for every nest egg, stale or dirty egg that he takes to market, and he likewise suffers for the mould and odor imparted by the loose methods of the general merchant. He suffers for the careless handling of the transportation company; eggs in cases unprotected from the sun on a railway platform or in hot freight cars, which are little less than huge incubators, deteriorate rapidly. He suffers from the mis-branding of the eggs in the hands of the retailer. He, more than anyone else, is interested in a more simple and more direct method of handling the product.

A system that will secure the eggs from the producer on a candled, i. e., on a graded basis, so that he will receive a first-class price for a first-class product, thereby putting a premium on freshness and cleanliness, would be most helpful. This, coupled with

transportation under carefully guarded shipping conditions and honest handling by the retailers, would result in putting into the hands of the consumer a clean, wholesome, nutritious food product at a price much less than what is now paid for a very indifferent article and at the same time would increase the profits to the producer.

DIRECT MARKETING

When eggs can be delivered by the producer direct to the consumer, it is an ideal way of marketing the product and should be followed more extensively than it is; however, only a comparatively insignificant number can be handled in this way. The suburban and city lot poultryman should certainly stimulate such a trade. Indeed, it is only by so doing that he can successfully compete with the cheaper production under farm conditions.

Marketing through the creamery has much to commend it and has been tried with some success.

COST OF LIVING

This investigation has developed the following deductions relative to cost of living:

	No. of eggs	Value	No. of poultry	Value
12 town families each consume per year.....	916	\$16.77	21	\$ 9.95
18 farm families each consume per year.....	1,056	18.41	28	13.76

The average size of these families in both town and country was four persons, which included all those who ate regularly at the table.

	No. of eggs	Value	No. of poultry	Value
Average per individual, town, per year.....	229	\$4.19	5	\$2.48
Average per individual, country, per year....	264	4.60	7	3.44

For this particular food product the cost of living was higher in the country than in the towns. This is attributable to the larger amount consumed per individual on the farm. It is also probable that families living in town and keeping a few fowls consume considerably more both of poultry and eggs than families not keeping them.

SUMMARY

1st. Poultry constitutes a very good minor source of farm income. It should be considered, however, that "profit" as considered in this circular is the net returns above cost of feed and labor; that no rent has been charged for the use of the land, nor have any overhead charges been included. Both these factors are undetermined, but must be considered before a clear profit can be counted. Under farm conditions the poultry usually have the run of the farmyard, orchard and nearby fields, as we have seen, much to their advantage. It is a little difficult to say just how much the poultry should pay the farm for this privilege. A pasture charge is certainly just. In this investigation we have allowed this charge to be balanced by the overhead credit that was due the flock for the destruction of insects, worms, weed seeds and gleanings from the grain fields, orchards, garden, etc., that were thus saved and converted into a source of profit. However, before the merchant or manufacturer counts a profit, he deducts an overhead charge sufficient to cover depreciation and insurance and numerous accidental sources of loss. For instance, merchants in towns along the rivers where their stores are subject to inundations by high water, add a "flood charge" to the selling price of their goods sufficient to cover any contemplated loss, figured on past experience. There are a number of such overhead charges incident to the poultry business. One of our cooperators lost his entire flock of young chicks by a destructive hailstorm at a time in the season too late for him to hatch others. Rats did the work of destruction in another flock. Hawks, crows, skunks, weasels, foxes, chicken thieves, roup, cholera, white diarrhea, failure of the eggs to hatch, hens leaving the nest, incubator and brooder trouble, are all factors that directly influence the profit to be derived from the poultry business, and some of which, under farm conditions, are sure to come at some time. Before the enterprise is profitable it must be able to show a clear profit above such incidental losses through a long period of years. To ascertain how much the overhead charges should be will be a part of the future work of this investigation.

2nd. Both in town and country small flocks have given greater profits per fowl than large flocks.

3rd. Flocks with unlimited range have shown better profits than flocks that were partly or wholly confined.

4th. Farm flocks have been more profitable than village or city lot flocks.

5th. To successfully compete with the farm flocks the village or city lot poultryman must keep high producing hens and sell at a higher price.

6th. Poultry "systems" requiring close confinement of the flock and a large amount of personal attention are out of place on a general farm. The poultry should be incidental to the main business of the farm.

7th. Farm and village lot poultrymen are serious competitors with the commercial poultrymen. The surplus from all these small flocks pours upon the market a continuous stream regardless of profit. The commercial poultryman devoting all his time to the business sends to the market a produce, the price of which is largely governed by supplies furnished by his competitors and to whom the business is only an incident.

8th. A better system of marketing eggs and poultry is needed; one which will encourage the production of a high-class product and insure expeditious and careful transportation to the consumer.

This circular is submitted to the farmers and poultrymen of the State as being conclusive only in so far as the particular flocks involved are concerned, and as an indication of the conditions surrounding the industry. We hope poultrymen and farmers will question these figures and give the Experiment Station the benefit of the results of any experiments or data that they may have bearing on the questions involved. The Station wishes to continue this investigation with a larger number of flocks cooperating and will for the present continue to supply blanks to those who wish to do careful, accurate, painstaking work.

ACKNOWLEDGEMENTS

The computations upon which the deductions in this Circular are based have been largely the work of Mr. M. R. Cooper, chief computer and of Mr. J. S. VanOver, both of the Department of Cooperation.

Ohio Agricultural Experiment Station

CIRCULAR No. 119

WOOSTER, OHIO, DECEMBER 29, 1911

COOPERATIVE FORESTRY WORK

By EDMUND SECREST

The Experiment Station is prepared to give practical assistance to land owners in the management of timber tracts and woodlots, in the establishment of commercial tree plantations, shelter belts, windbreaks, and in reclaiming waste land by forest planting.

The purpose of this cooperative work is to establish in suitable localities examples of forest management, woodlot improvement and forest planting, which shall serve for demonstration and experimental purposes.

The Station believes the native woodlot to be the fundamental factor in Ohio forestry, and it is desirous of coming in contact with those parties who possess such woodlots, and who wish to preserve them and increase their productivity. The great majority of farm woodlots are in an unproductive condition, and are often maintained at a loss to the owners. The fundamental principles of woodlot management are well known but there are certain classes of woodlots which present problems in the matter of improvement, and which make some experimental work necessary.

NATURE OF ASSISTANCE GIVEN

The assistance rendered is advisory by means of inspections and detailed plans prepared by a representative of the Experiment Station.

The plans will include full and comprehensive instructions for the necessary work upon the tract examined, based upon a study of its possibilities and needs. In the event of a forest plantation of any description, they name the proper species for planting, give instructions for the preparation of the ground, and for the spacing and

setting of the young trees. For woodlots or large forest tracts, suggestions are given as far as possible, relative to the cutting and marketing of mature and weed trees, the thinning of second growth stands, the replanting of areas cut-over, planting among thin stands, and underplanting to preserve or create good forest conditions. Information will be given relative to the care of the existing trees and methods to be followed in order to secure the perpetuation of the forest, by natural regeneration of valuable species. In some cases plans are supplemented by maps.

When it is impossible to determine accurately what should be done or when conditions are problematical, the Station is prepared to establish experimental operations, working toward a solution of the problems.

Under these conditions it will in some cases furnish seeds or nursery stock when needed in the execution of the planting or working plan, otherwise, all nursery stock, either seed or trees, will be charged for at a nominal rate. By paying for nursery stock, however, the cooperator is not released from his obligation to the Experiment Station respecting reports to be made upon the condition of the planting, or access to the planting for the purpose of procuring data for publication. It is expected also that the directions of the Station with respect to the care and management of the tract or planting will be carried out.

REGULATIONS GOVERNING COOPERATIVE WORK

No charge is made for field examinations, planting or working plans, but it is expected that transportation of the Station representative from the nearest railroad point to and from the land to be examined will be provided by the owner, also subsistence during the time required to make the examination or plans.

HOW TO MAKE APPLICATION

Persons desiring the services of the Experiment Station in accordance with the provisions outlined in this circular, are requested to fill the application blank on the back or make application by letter to the Forester of the Experiment Station.

Application for services should be made as far in advance as possible, so that the necessary attention may be given thereto in due time.

GENTLEMEN:

I have read carefully your circular regarding Cooperative Forestry work and would say that I shall be pleased to go ahead with the work under the conditions therein specified and to have your Forester visit me to make the plans at such time as seems wise to you.

I shall be pleased to meet him at _____
Railway or traction station

which is _____ miles _____ from where I live or at
Direction

_____ which is _____ miles _____

from where I live or at _____

I shall wish about _____ days notice and am connected with the
_____ telephone exchange _____

The plot I wish to use in the work contains about _____ acres,
which may be described as follows: _____

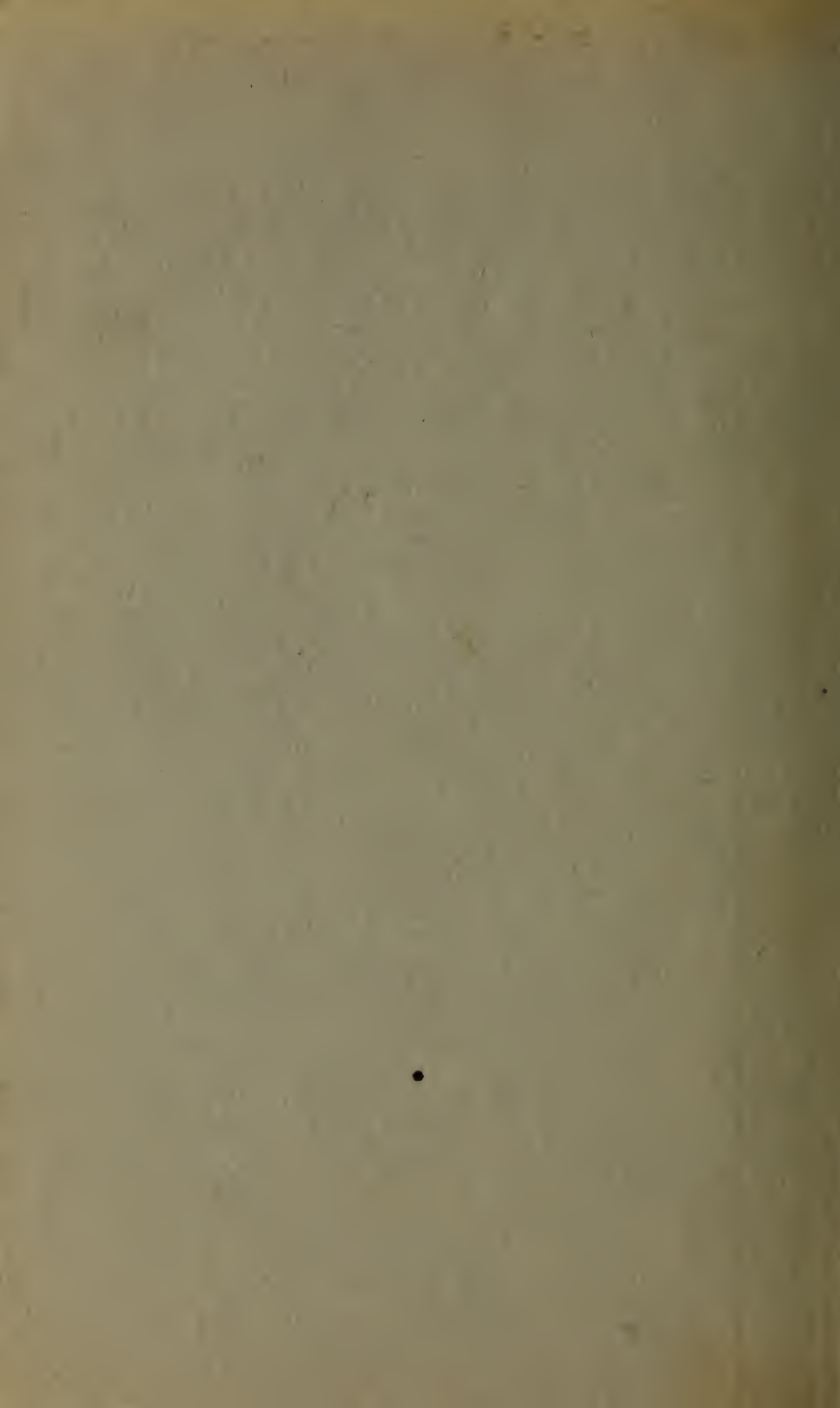
It is situated in _____ township and
_____ county.

Signed _____

P. O. _____

Date of mailing _____

Address to FORESTER, O. A. E. S.,
Wooster, Ohio.



UNIVERSITY OF ILLINOIS-URBANA



3 0112 001706602